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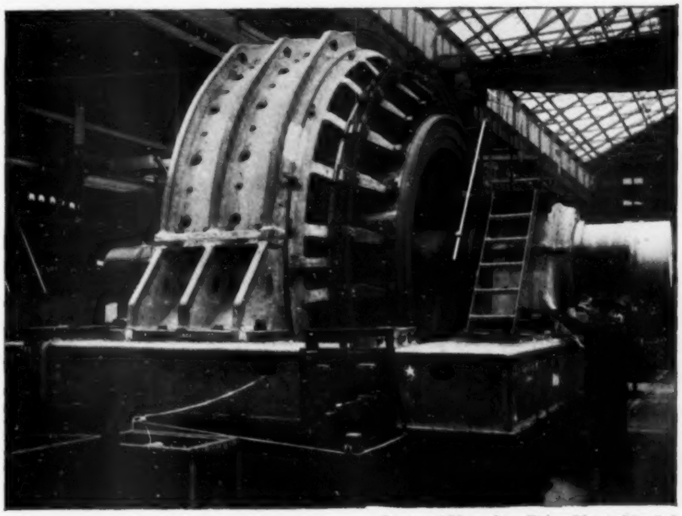
ELECTRIC DRIVES FOR ROLLING MILLS

Many notable achievements have been accomplished during the past year in improving the efficiency of rolling mills, and the revival of the iron and steel industry has enabled the installation of electrical equipment for this purpose. In this article installations are briefly reviewed which are either completed or in progress.



Courtesy of Metropolitan-Vickers Electrical Co., Ltd.

Reversing Mill Motor, 15,000 h.p. d.c. (maximum 15,500 h.p.) for driving a 34" reversing universal mill for the Cargo Fleet Iron Co., Ltd.

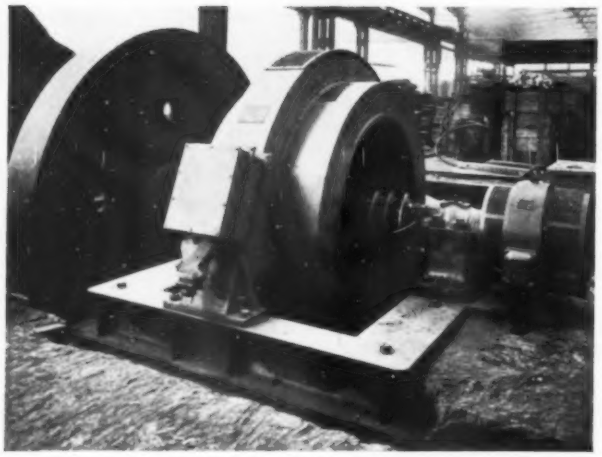
IT is logical to assume that increased competition in the ferrous and non-ferrous industries should have a considerable influence on technical progress. Keen competition causes new conditions to arise, and even the most established firms are forced to realise the necessity of preparing to meet them more effectively. Progress is possible by improving the materials employed, or the technique involved in the manufacturing processes, and by taking advantage of the best research facilities available. These are necessary to effect all possible economy in production, while maintaining or increasing the quality of the product. In improving technique many notable achievements have been accomplished in mechanical progress, from the raw material to the finished article. In these developments the use of electricity is having a very important influence; the improved designs in motors and controlling devices, for instance, are such that entire mills are now electrically equipped and operated, while blast-furnace operations are being expedited as a result of the increasing use of electrical appliances.

The revival of the iron and steel industry has naturally resulted in the further application of electrical equipment, and, in particular, an exceptionally large number of rolling mill drives has been put into operation during the past year. Among the most noteworthy of the orders for electrical equipment for rolling mills received during the year by the Metropolitan-Vickers Electrical Co. are the complete equipments for a large reversing mill and a skin-pass mill for the new steel plant of Messrs. Richard Thomas and Co., Ltd., at Ebbw Vale, South Wales. This also includes five motor-generator sets for 230 volts d.c. auxiliaries.

This reversing mill equipment comprises a 7,000/19,300-h.p. reversing d.c. mill motor, supplied from a flywheel generator set, consisting of three main 1,870 kw. d.c. generators and a 30-ton flywheel driven by a 5,000-h.p. slip-ring induction motor. The latter machine is controlled by an automatic liquid starter and slip regulator. For this equipment a completely automatic system of control is provided, which eliminates the possibility of damage due to careless handling on the part of the operator. The driver only needs to put the controller straight over and the control gear automatically provides for limitation of the peaks and rates of acceleration and deceleration, so so that the circuit breaker is tripped and the mill shut down only in cases of emergency. The control of the fields and limitations of peaks are obtained by suitable design of special exciters. This system has the advantage that the number of operating devices for control is reduced to a minimum, thereby increasing the reliability of the equipment.

The skin-pass mill equipment consists of an 800-h.p., 400/800 r.p.m., d.c. motor driving the mill itself; a 400-h.p., 300/1,050 r.p.m., d.c. motor driving the tension reel, and two 25-kw., 400/1,600 r.p.m., d.c. generators on the drag reel. These machines are supplied from a 1,600-h.p. induction motor generator set comprising a 960-kw. main Ward-Leonard generator, a 75-kw. bucking generator for the tension reel motor, a 25-kw. booster generator for the drag-reel generators, also a 20-kw. pilot exciter and two small exciters for tension regulators. The five auxiliary motor-generator sets each comprise a 1,500-kw. d.c. generator driven by a 1,700-k.v.a., 2,160-h.p. synchronous motor complete with exciter. These machines are for supplying the 230-volts d.c. mill auxiliaries operating throughout the steel plant.

The hot- and cold-rolling of wide strip has assumed prominence during the year, and the British Thomson-Houston Co. has in course of manufacture the drive for the roughing end of a continuous hot-rolling wide-strip mill for the same company. This drive comprises four synchronous motors, each of 2,500 h.p., for driving the hot-stands, a 700-h.p. motor for the slab reducer, a 600-h.p. induction motor for the scale breaker, and two 200-h.p. d.c. motors for the vertical edgers. The Ebbw Vale plant will also have the first mill in this country for the cold-rolling of tinplate strip by a continuous process, and the electrical equipment for this is at present being manufactured at the British Thomson-Houston works. It comprises four 1,000-h.p. d.c. motors, and one 400-h.p. d.c. motor, each of which drives one of five tandem stands, and one 200-h.p. d.c. reel motor, together with a common



700 h.p. induction motor installed in a rolling mill by British Thomson-Houston Co., Ltd.

motor-generator set and complete control gear, the latter being of a very special nature, necessitated by the high accuracy of gauge required on this mill.

An interesting equipment by Metropolitan-Vickers Electrical Co. is now in course of installation at the Middlesbrough works of the Cargo Fleet Iron Co., Ltd., for driving a new 34-in. reversing universal mill. The mill comprises two three-high stands direct-coupled to the main 5,000 h.p. mill motor. When rolling slabs the second stand is disconnected, and the first stand is operated as a two-high reversing slabbing mill. When rolling rounds and sections both stands are brought into operation, and the unit is operated on the three-high principle with tilting tables.

The equipment consists of a 5,000-h.p., 55/140 r.p.m., reversing d.c. mill motor with a maximum peak of 15,500 h.p., and a 530-h.p. reversing d.c. mill motor driving the two edging rolls through bevel gearing. These two units are supplied by a 4,620-kw. flywheel motor-generator set driven by a 5,500-h.p., 11,000 volts, induction motor running at 740 r.p.m. The order also includes the necessary ventilating equipment for both the main mill motor and the motor-generator-set house, also some 50 motors complete with contactor control equipment for the auxiliary mill drives, such as screw-downs, tilting tables, working roller tables, etc.

The method of driving the live rollers is an interesting feature of the auxiliary equipment. This comprises 91 direct-coupled live roller motors supplied from a low-frequency motor alternator set, providing an 11·5-cycles supply to give the necessary low speeds on the individually driven rolls.

Another important equipment in course of manufacture by the same company is for Messrs. John Lysaght, Ltd., Newport, and is designed for driving two four-high cold-roll mills. The equipment comprises two 1,000-h.p., 300/600-r.p.m., 600-volts d.c. mill motors, each driving one mill, and supplied from a motor-generator set consisting of two 800-kw. generators driven by a 2,600-h.p., 6,000-volts synchronous motor. The control is on the Ward-Leonard principle, and is operated from panels situated on the mill housings. The panels have controls for the motor-operated field rheostats (generator and motor), also an ammeter and speed indicator. A feature of these panels is that on them are mounted turn indicators which show the position of each end of the rolls. This is accomplished by coupling a Selsyn transmitter to each screw-down motor, of which there are two, one for each end of the rolls. The Selsyn transmitters are coupled to Selsyn receivers, which operate the turn indicators and so indicate the movement of the screw-down motors.

In order to obtain increased output at the Corby works of Messrs. Stewarts and Lloyds, Ltd., the 40-in. blooming mill equipment, previously supplied by Metropolitan-Vickers, has been reconstructed and a new 32-in. intermediate reversing mill added. Part of the work previously done on the 40-in. mill is now to be allotted to the 32-in. mill. For the 40-in. mill equipment the existing mill motor is retained, but is supplied from a new flywheel motor-generator set. The revised rating of the mill motor is 5,000 h.p., with a peak capacity of 17,200 h.p., the speed being ±0/60/120 r.p.m. The new flywheel motor-generator set for this mill motor is driven by a 4,000-h.p., 11,000-volts, slip-ring induction motor, and has a flywheel with a stored energy of 150,000-h.p. secs. at 750 r.p.m.

On the 32-in. intermediate mill equipment the new mill motor has a rating of 5,000 h.p., with a peak capacity of 13,200 h.p., the speed being ±0/80/160 r.p.m. This mill motor is supplied from the existing flywheel motor generator set which has been removed from its original position near the 40-in. mill for that purpose. The set is driven by a 3,000-h.p. slip-ring induction motor, with a flywheel of 120,000-h.p. secs., and the only change consists in reconnecting the generators to suit the voltage of the new mill motors.

Both these mill equipments are controlled by the new scheme first supplied by Metropolitan-Vickers for the Briton Ferry equipment. Briefly, the control of the fields and limitation of peaks are obtained by a suitable design of special exciters. This system has the advantage that the number of operating devices for control is reduced to a minimum, thereby increasing the reliability of the equipment. The equipment also includes the ventilating apparatus for the house containing the mill motor and Ilgner set for the 32-in. mill, also several motors for the continuous mill.

The British Thomson-Houston Co. has completed the installation of a sheet-rolling mill drive for a mill-rolling electrical plant. The drive comprised a 700-h.p. induction motor with a slip-regulating phase advancer. This equipment was unique in that in addition to returning slip energy to the line, it also corrects the induction motor-power factor at all loads. A further sheet-mill installation comprised a 750-h.p. induction motor for driving a mill producing stainless sheet.

Manufacture was completed and installation commenced of a 4,500-h.p. synchronous induction motor for driving a continuous billet rolling mill at Messrs. Stewarts and Lloyds, Ltd., Corby. This is believed to be the largest synchronous induction motor ever built, and comprises a a salient-pole synchronous motor with an independent motor winding in the pole faces. This type of motor combines the advantages of power-factor characteristics and large air gap of the salient-pole synchronous motor, and the starting characteristics of the induction motor. Also completed as part of the same installation are two 2,000-h.p. induction motors driving tandem billet mills, and three 500-h.p. d.c. motors with common motor generator set driving edging stands.

As an example of the electrification of existing steam-driven mills, there is in course of manufacture a large reversing equipment for the Shelton Iron, Steel and Coal Co., Ltd. The motor on this equipment is rated 3,800 h.p., 62/160 r.p.m., and is designed for a maximum peak load of 11,400 h.p. For supplying the motor a flywheel motor-generator set is provided.

Another example of a drive for a continuous cold-rolling mill, at present being manufactured at the British Thomson-Houston works, comprises three 250-h.p. motors driving tandem stands, and two 60-h.p. motors driving reels. These are supplied from a synchronous motor-driven, motor-generator set. Here again the greatest interest centres in the control of the speed range up to 160 r.p.m., and capable of dealing with peak loads up to three times full load. This motor is supplied from a 900-kw. synchronous motor-generator set, which also supplies power for an edging mill motor. The order also covered the d.c. switchgear and control gear for the whole mill. The

(*Continued on page 84.*)

Progress in Cast Iron

By L. W. BOLTON, A.M.I.Mech.E.

Recent years have seen great improvements in the properties of cast iron, resulting from intensive research in this and other countries, and to-day it is amongst the most generally useful engineering materials. Progress in the improvement of strength by the introduction of alloys, by improved methods of melting, and by heat-treatment, and the engineer can be provided with iron castings having strengths up to 25 or even 30 tons per sq. in. In this article the author briefly reviews these developments.

THE steady increase in production witnessed in the ironfounding industry during the past year has to a certain extent been due to the improved trade conditions and consequent demands made by the allied industries, but, in addition, has been aided considerably by the interest taken by the founder in improving his product, especially in regard to the influence of alloy additions. Improvements in the quality of iron castings over the past few years have resulted from the attention paid to melting technique, sand control, and sand-conditioning plant, but there is no doubt that a better understanding of the metal itself has played a most important part.

Probably the greatest advance recently made has been in the production of higher strength cast irons. At the end of the Great War cast iron was generally considered, a material with a tensile strength of about 12 tons per sq. in., but nowadays castings are produced with tensile strengths approaching 30 tons, and although they were first produced a few years ago, the last year has seen an increase in the applications of high-strength cast irons in the industry, mainly because the engineer is finding that these cast irons can be consistently produced and compare favourably with many other materials.

High-strength Cast Irons

High-strength cast irons can to-day be divided into two classes, first those known as alloy cast irons, where special alloys are added to the metal, and secondly, where high strength is obtained mainly by careful control of the carbon and silicon content of the metal. Both of these types are relatively low-carbon irons, and may be improved still further by a suitable heat-treatment.

The well-known inoculated irons, produced by melting metal which would normally solidify white, but which, after treatment in the molten condition by a graphitiser, yield a close-grained grey iron with excellent physical properties, are an example of obtaining high-strength grey iron without the use of alloy additions. Such irons can, of course, be further improved by the use of small amounts of certain alloys.

In producing these irons, a powdered graphitiser is usually added to the metal as it is tapped into the ladle, but during the year attention has been drawn to a new process where the white, graphite-free molten metal is inoculated or greyed by small additions of molten grey iron. Two furnaces are needed, and this process has become known as the two-cupola process. One cupola melts a mixture composed mainly of steel, with ferro-silicon and ferro-manganese, yielding a low total carbon iron of which the following is a typical analysis: Total carbon, 2·40%; silicon, 1·35%; manganese, 1·0%. The other cupola melts an ordinary soft iron with a total carbon content of, say, 3·25% and a silicon of 2·5%. A predetermined amount of the soft iron is poured into a ladle containing the hard iron, and the resultant metal produces castings which are finer grained and of higher strength than those made from metal of a similar analysis, but melted in the ordinary way in one cupola. Apart from its higher strength, the metal has a greater freedom from internal draws and shrinkage and is very suitable for the manufacture of castings for use at high pressures, as, for example, pumps and valve castings.

Pearlitic Malleable Cast Iron

Another development at present taking place both in this country and abroad is concerned with the use of metal of a somewhat similar composition to the above mentioned inoculated cast irons, except that in this case a graphitiser is not used. The material is white in the as-cast state, but is heat-treated to spherodise the free cementite and produce a metal with between 5 and 10% elongation on a 2 in. parallel and a tensile strength of approximately 45 tons per sq. in. This material has become known as pearlitic malleable cast iron, and here again small alloy additions have been proved to be beneficial under certain conditions.

Special Cast Irons

Many of the cast irons which have been developed to meet special engineering requirements—for example, heat- or corrosion-resistance, abrasion, or shock-resistance—have been termed special cast irons, and it is interesting to note that quite recently an attempt was made on the Continent to define these irons. Special irons were defined as those containing elements not regularly entering into cast iron, these being specially added to secure some particular properties. Additions of these elements were not considered as making an iron special unless they existed in a certain minimum amount, as, for example, 0·30% nickel, 0·30% chromium, 0·30% copper, 0·15% titanium, 0·10% vanadium, 0·10% molybdenum, 1·5% manganese, and 5·0% silicon. In this country no attempt has been made to define a special cast iron, and there are many well-known compositions which, while containing no alloy addition, yet, on account of their low total carbon or special structure yield properties that might well warrant the application of the term "special."

Alloy Cast Irons

Alloy irons have been developed to meet various service conditions, with a large amount of success, and in this country has been done mainly by the use of additions of one or more of the following elements: Nickel, copper molybdenum, chromium, and aluminium. It will be seen that although progress is being made in the production of cast irons with superior physical properties without the use of alloy additions, the main developments have been in the direction of the use of alloying elements. Although no outstanding new developments have occurred in this field during the past twelve months, the large amount of experimental work which is being carried out has resulted in a greatly increased use of special elements, and it will perhaps be of interest to review briefly the present position with regard to the use of alloy additions.

Nickel.—This element still holds its place as the most widely used of all the alloying elements in cast iron. The addition of small amounts of from 1·0 to 2·0%, especially in replacing a part of the silicon content in intricate castings when the section varies widely in different parts, is a

valuable aid to producing homogeneous metal. This element acts as a softener in thin sections, but yields a hard and dense metal in thick sections. Several large foundries, producing castings in which high strength and machinability as well as hardness and wear resistance are required, as, for example, in machine tools, now regularly use a nickel addition of up to 1·5%.

Higher nickel additions of the order of 3·0 to 6·0% yield irons which have valuable abrasion and wear-resisting properties, those with the lower nickel content being particularly suitable for heat-treatment. With the higher nickel content, grey irons can be produced with air-hardening properties. This range includes the special iron developed by the International Nickel Co., known as Ni-Hard, in which it is possible to obtain an intensely hard chill due to the formation of martensite. This iron has been successfully used in this country during the year in the manufacture of small rolls for strip steel and in crushing and grinding equipment.

With higher nickel additions of from 12·0 to 20·0% the austenitic irons are produced, of which Niresist and Nicrosilal are well-known examples. These irons have special heat and corrosion-resisting properties, making them very suitable for use in such applications as furnace parts, internal combustion engine parts, and for pumps, etc., in the mining and chemical industries.

Chromium.—The hardening and carbide stabilising action of this element is well known, and small additions are often made along with nickel. Small additions of chromium alone, of the order of 0·5 to 1·0%, improve heat resistance under certain conditions. Increased chromium of between 20·0 and 35·0% yields a hard white iron which is extremely corrosion-resistant, and also useful under high temperature corrosive conditions.

Cast irons containing between 27 and 30% chromium have recently been proved very successful in resisting corrosion when used in equipment for the handling of water from coal mines. A small addition of nickel improves the strength of these irons, and also serves to eliminate many foundry difficulties.

Molybdenum.—Much experimental work is still being carried out on the influence of this element when added to cast iron. It is now generally accepted that its action on the structure is rather complex, and depends partly on the composition of the base iron and partly on the amount added. Small additions of 0·3 to 0·7% have proved very effective for improving strength, and this element has been found especially valuable in cases where resistance to fatigue and shock are required. Many applications have been found in the automobile industry, and molybdenum cast iron is now being used for brake drums, crank and camshafts, gears, valve seats, etc. Improved results have also been obtained with molybdenum additions in the roll-making industry.

Copper.—One of the well-known applications of copper as an addition to cast iron is in the high-nickel austenitic iron, "Niresist," which normally contains 7% of this element. In the absence of nickel, the limit of solubility of the copper in cast iron is less than 4·0%. Small additions of this element, 1·5 to 2·5%, have been used in some of the newly developed cast crankshafts, where it is said to increase the fluidity of the molten metal and also improve its resistance to impact.

It has also been recently stated that copper in small amounts reduces the atmospheric corrosion of grey cast iron.

Aluminium.—It has for some time been realised that additions of this element confer valuable heat-resisting properties to grey cast iron, an aluminium content of 8·5 to 15·0% yielding an iron which is almost completely resistant to oxidation at temperatures up to 800° C. Hitherto difficulty has been experienced in obtaining sound castings when appreciable amounts of aluminium are added because of the formation of aluminium oxide. Work which is at present being carried out by the British Cast Iron Research Association shows that these difficulties may be overcome, and there appears to be a future for this metal as an alloy addition in the production of extremely heat-resistant cast irons.

The recently developed nitrogen-hardening cast iron contains small amounts of aluminium together with chromium. These irons have been increasingly used during the year for cylinder liners.

Forthcoming Meetings

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Jan. 29. "Special Cast Irons," by J. G. Pearce, M.Sc.

LONDON SECTION.

Feb. 11. "The Construction of Alloys," by C. H. Desch, D.Sc., F.R.S.

SCOTTISH SECTION.

Feb. 15. "Copper and Its Alloys in the Automobile Industry," by D. P. E. Neave, M.A.

SHEFFIELD SECTION.

Feb. 12. Joint meeting with the South Yorkshire Section of Institute of Chemistry.

SWANSEA SECTION.

Feb. 9. "Strip Rolling," by W. R. Barclay, O.B.E.

MANCHESTER METALLURGICAL SOCIETY.

Jan. 20. Joint meeting with Iron and Steel Institute.

INSTITUTE OF MARINE ENGINEERS.

Feb. 9. "Welding Research and Practice," by Prof. B. P. Haigh.

IRON AND STEEL INSTITUTE.

Jan. 26. Joint Meeting with Lincolnshire Iron and Steel Institute at Cole Street School Rooms, Scunthorpe. Subject: "The Constitution of Blast-Furnace Slags in Relation to the Manufacture of Pig Iron," by Mr. T. P. Colclough.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Jan. 23. Annual Dinner and Dance.

Feb. 5. "High Duty Alloy Cast Iron," by A. B. Everest, B.Sc., Ph.D.

EAST MIDLANDS BRANCH.

Jan. 23. "A Refresher in Cast Iron Metallurgy," by A. E. Pearce.

LANCASHIRE BRANCH.

Feb. 6. Annual Dinner.

BURNLEY SECTION.

Feb. 9. "The Making of a Pattern Plate," by R. Swain.

LONDON BRANCH.

Feb. 3. "Steel Castings," by J. Deschamps.

EAST ANGLICAN SECTION.

Jan. 21. Annual Dinner.

Feb. 4. "Some Considerations of Cupola Operation," by H. H. Shepherd.

MIDDLESBROUGH BRANCH.

Feb. 19. "Textile Engineering in Relation to General Aspects of Cupola Practice," by J. Jackson.

NEWCASTLE-ON-TYNE BRANCH.

Jan. 23. "Further Developments with Coal Dust in Moulding Sands," by B. Hird.

SCOTTISH BRANCH.

Jan. 26. "Cast Iron and Its Applications to Engineering," by A. Campion, F.I.C.

Feb. 13. "Gates and Risers," on—
(*a*) Large Non-ferrous Castings, by A. Dunlop.
(*b*) Small Non-Ferrous Castings, by J. M. Douglas.

FALKIRK SECTION.

Feb. 1. "Sands and Facings with Reference to Light Castings for Enamelling," by H. McNair.

SHEFFIELD BRANCH.

Feb. 4. "The Heat-Treatment of Castings," by Dr. R. Hunter.

WALES AND MONMOUTH BRANCH.

Jan. 23. "Ingot Moulds and Heavy Castings," by J. Roxburgh (at Newport).

Jan. 30. "Moulding Castings for Vertical Pump Motors," by T. W. Trayherne (at Bristol).

Feb. 13. "Dimension Tolerances for Castings, with Particular Reference to Malleable Cast Iron," by R. J. Richardson (at Cardiff).

WEST RIDING BRANCH.

Feb. 13. "Modern Methods in the Core Shop," by W. H. Smith.

ELECTRODEPOSITORS' TECHNICAL SOCIETY.

Feb. 10. "Symposium on Bright Nickel Plating."

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Ferrous and Non-Ferrous Metals
Boom Conditions

THE expansion experienced in the majority of the engineering, shipbuilding and manufacturing industries throughout the past year has had a remarkable influence on the production and price of practically all the metals employed. Probably the most outstanding are the conditions in the iron and steel industry, which has had what can be regarded as a phenomenal year. During the year production reached the record figure of 11,698,200 tons—an advance of 18·7% compared with 1935, which had established a record. Pig iron output, too, shows an increase on the 1929 high level, and an expansion of 19·6% over the 1935 level at 7,685,700 tons.

There are no signs of the demand for iron and steel abating, as all the consuming industries seem to be enjoying a boom period, in fact, if there were greater capacity there is no doubt it could be profitably used. The immense demand, direct and indirect, resulting from the rearmament programme, together with the heavy requirements of the building, engineering and shipbuilding industries has strained the present capacity of the iron and steel industry. For this reason it was necessary to modify import duties to facilitate consumers obtaining supplies of certain semi-finished products.

During the major part of the year the iron and steel prices have remained very steady, but, during the last two months in particular, consumers were asked to bear increased prices. Since the turn of the present year further increases in the price of steel have taken place which are bound to have some effect on future demand, unless further arrangements can be made to import requirements at a more competitive price. Increases in the price of steel will certainly hamper the shipbuilding demand, which is at present experiencing a welcome revival.

Although supply and demand will continue to be important factors in determining the prices of commodities, the maintenance of stable prices for the basic materials consumed is a potent factor in the success of the engineering, shipbuilding and manufacturing industries and yet, of the main metals consumed, tin is the only one which did not reach a new peak price during 1936. It is true, of course, that metal consumption is somewhat irregular throughout a year. There are seasonal fluctuations which have an influence on metal price movements and normally a reduction in the demand for non-ferrous metals is experienced in December. In 1936, however, copper, lead and spelter reached their highest levels for several years during the last few days of the year.

Copper opened the year at a relatively low level, and although the operation of the international copper scheme seemed to indicate that variations in prices would be between relatively narrow limits, the difference between the highest and lowest prices amounted to £14 18s. and exceeded the 1935 difference by nearly £5. Fortunately no heavy fluctuations were experienced; the lowest price was recorded in January and throughout the year there was a gradual rise to the peak in December. It was only during the last few months that efforts were made to increase output to meet a demand which has shown gradual improvement throughout the year, but the companies operating under the international scheme, which functioned throughout the year, consider that an unduly high price is not good for producers or consumers. To encourage the extension of the use of copper, however, the price should be stabilised at an economic figure.

The price of lead has shown greater fluctuation than copper throughout the year, although, as in the case of copper, the price was at a low level in January and reached its highest in December, but while gradual increases took place during the first few months a setback was experienced in May which reached the lowest level of the year in June. Prices gradually increased again to September when there was a sharp jump, followed by an even sharper increase in November. From June to December the prices showed a difference of £9 13s. 9d.

Although the production of lead has improved slightly it is not sufficient to meet current consumption and, as has already been shown this year, prices will continue to rise until the price level stimulates greater activity in mining centres where production, during recent years, has been on a restricted scale.

From the consumers' point of view spelter conditions during 1936 were more favourable. Increased production has been stimulated in several consuming countries, and the price which was lowest in March remained stationary until October, November and December showing a sharp rise. From the producers' standpoint the position is unsatisfactory as the price shows a difference in favour of lead by about £8 when normally the difference in the market prices of these metals is favourable to spelter by about £3. It is not surprising that further advances in price have taken place during the last few weeks.

Considerable fluctuations were experienced in the price of tin and the range between the lowest and highest price in the year was unusually wide at £69 7s. 6d. Wide fluctuations took place during the first five months and in May a sharp decline was experienced the price falling to the lowest levels in June and August. A sharp increase was shown in September, and prices rose substantially in November and December. From the consumers' point of view the supply remained unsatisfactory during the year, and the prolonged negotiations of the members of the International Tin Committee, to reach an agreement on quotas, did not assist in relieving the position.

Other important metal producers continued their policy of stimulating consumption by means of a fair and stable price; notable examples being the aluminium and nickel producers. During the year aluminium was quoted at £100 per ton and nickel from £200 to £205 per ton and the results of this stable price policy has been very favourable. Both these metals are claimed to have reached a production record during the year, while consumption in each case has made good progress. Elsewhere reference is made to the substantial reduction in the price of nickel which took effect at the beginning of the present year, which is a further indication of the producer's policy to stimulate consumption. Special reference is made in this issue to another metal, magnesium, which is being developed rapidly.

Generally, the boom conditions, experienced during the latter part of 1936, show every sign of continuing, unless something of a political character interferes with normal circumstances, and restrictions on output may be affected.

The Output of Magnesium

British Production Developments

THE intensive search for alloys combining good mechanical and physical properties with low specific gravity has added considerable impetus to the activities in magnesium and magnesium-alloy developments. The extraction of the metal from its ores, the available alloys, their casting, fabrication and protection against corrosion has been the subject of intensive study, resulting in the passage of magnesium alloys from the field of unstressed and lightly stressed parts to that of medium stressed components. The transition to the field of more highly stressed parts is the next step in this sequence, and the indications are that the very near future will witness greater advances than have been experienced in this industry. As yet, however, the actual output of magnesium is relatively small to meet any possible future increased demand, and efforts are being made to increase production.

The advantages offered by the application of magnesium has been freely recognised by the aircraft industry, and rapid progress in its use has been made. In an industry where power-weight ratios have always been of the greatest importance this attitude was to be expected, but the same ideas are spreading to other industries and the demand for magnesium is growing. It is not surprising, therefore, that active steps are being taken to increase the output of British magnesium, which, according to a recent Bulletin of the Imperial Institute,* has been mostly imported from Germany and the United States, but one British firm recently started production, and anticipates an output of 150 tons per month in the near future.

Raw Materials

Nearly all the magnesium of commerce is produced by the electrolysis of magnesium chloride, but the raw materials and methods used differ considerably. In one case a natural source of the salt is utilised, such as carnallite (a double chloride of magnesium and potassium) or salts from magnesium brine springs, whereas in other cases the magnesium chloride is prepared from magnesite. Estimates indicate that about two-thirds of the magnesium now being produced is obtained from magnesite, the remainder being from carnallite or brines. With a considerably increased consumption of magnesium in the future it is probable that the chief raw material will be magnesite, but under special circumstances dolomite may assume some importance as a raw material.

Production in the United Kingdom commenced about April, 1935, following the formation of two companies by Murex, Ltd., in conjunction with Messrs. Johnson, Matthey and Co., who controlled certain fabricating patents. One of the companies, Magnesium Metal and Alloys, Ltd., confined its activities to the production of magnesium and magnesium alloys; the other, Magensium Castings and Products, Ltd., concerned itself with the manufacture of magnesium products. About this time a merger of some of the principal firms interested in magnesium was effected, resulting in the formation of Imperial Magnesium Corporation, Ltd., with a capital of £200,000, in which the participants were Magnesium Metal and Alloys, Ltd., the British Aluminium Co., Ltd., the Imperial Smelting Corporation, Ltd., and Imperial Chemical Industries, Ltd. In October last year it was announced that each of the parties to the fusion would continue their research and investigations individually. Magnesium Metal and Alloys, Ltd., under the control of Murex, Ltd., are continuing the manufacture of magnesium at Rainham. The raw material used is magnesite. The principal interest of Murex, Ltd., in Magnesium Castings and Products, Ltd., remains the same, and this Company is making products from magnesium and magnesium alloys at Slough.

Early last year a company was formed with a capital of £400,000 by F. A. Hughes and Co., of London. This company, known as Magnesium Elektron, acquired certain patent rights and processes, and a factory has been built at Clifton Junction, near Kearsley, the principal power station of the Lancashire Electric Power Co., where an output of 150 tons per month is shortly expected, with prospects of an increased amount in the near future. The process adopted is the electrolysis of fused magnesium chloride made from magnesite, imported from Greece and other sources.

According to the informative article[1] in the Bulletin mentioned, which deals with world production of magnesium, the demand for magnesium has outpaced the supply, but it is believed that the situation in this country will be considerably eased in the near future. The London price for magnesium ingots and sticks has for some time been about 1s. 6d. per lb.

* Bulletin of the Imperial Institute. Vol. XXXIV. No. 4. Price 2/9 post free.

1 *World Production of Magnesium.* Pp. 453-8.

Cheaper Nickel

THE announcement, on January 1, of a reduction in the price of nickel from £200/205 to £180/185 came somewhat as a surprise, especially as the present time may be regarded as one of industrial boom, with the general tendency of commodities to rise in cost. This reduction will be greatly appreciated, not only by the metallurgical industries, but also by consumers of the many ferrous and non-ferrous materials, into the composition of which nickel has come to be regarded as essential.

This reduction in price is really a continuation of the long-sighted policy adopted by the nickel producers to obtain more economic production, coupled with expanding markets, and to co-operate with their customers, not only technically, but also by sharing with them its profits resulting from the successful issue of such a policy. Despite the fact that manufacturers of both ferrous and non-ferrous alloys are constantly seeking, by means of research, to reduce the cost of their products without lowering their properties, by reducing or entirely eliminating nickel, the increase in the demand for nickel has been steadily maintained since the low point in 1932. Recent additions to the productive capacity were made during last year which have effected a better balance in production processes and added to potential output, and have provided the nickel industry with a reserve capacity to maintain prompt deliveries under any conditions which can reasonably be anticipated.

One of the most potent factors in this policy is the intensive research and development which has been adopted since 1922, not only on the production side, but on the uses of nickel. This has been rewarded by sound and consistent progress, and to-day nickel, either alone or in combination with other materials, has found so many applications in almost every branch of industry that the future can be surveyed with confidence, and the reduction in price of this metal is fully justified.

In a previous issue* reference was made to the policy of research and technical service of the Mond Nickel Co., and to the Company's new laboratory, recently opened at Birmingham, which is claimed to be one of the largest in Europe to be maintained by a single firm solely for metallurgical research. This laboratory is designed and staffed to enable the Mond Nickel Co. to co-operate still more closely with industry in solving the various metallurgical problems which involve nickel and its alloys, and also in carrying out fundamental research with a view to subsequent development of such materials in fulfilling those demands which will be made by the future trend of progress.

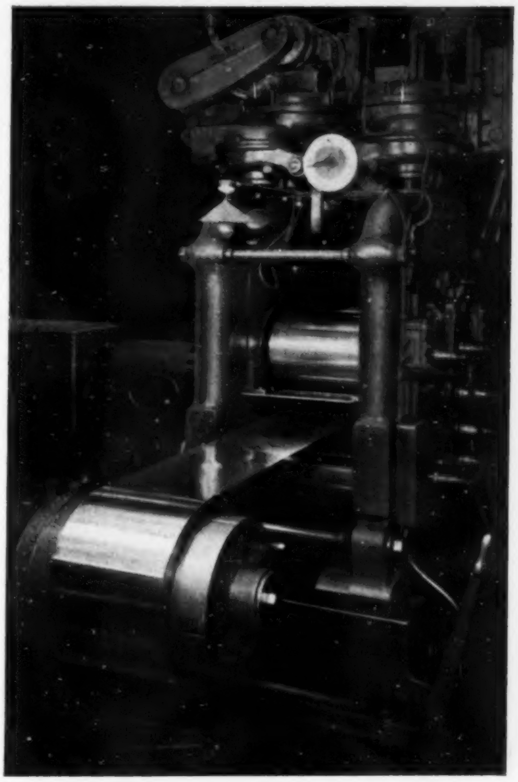
The steel industry, which is the dominant consumer of nickel, manufacturers of the many non-ferrous alloys, in which nickel is a constituent, and electro-platers will appreciate the importance of cheaper nickel, and this reduction will undoubtedly lead to its increased use.

* METALLURGIA. Vol. XV. No. 85. Pp. 1-3.

COLD-ROLLING DEEP-DRAWING STEELS—PART II.

By J. L. TURNER

The properties of deep-drawing steels are governed by details in manufacture, the conditions under which it is hot-rolled, subsequent cold-rolling and heat-treatment, and the reaction of these factors upon deformation. Some of these factors were discussed in the last issue, and in this article the author considers rolling pressure, cluster, and four-high mills, the principle of rolling, cold-rolling spread, and the influence of steel constituents on cold rolling.



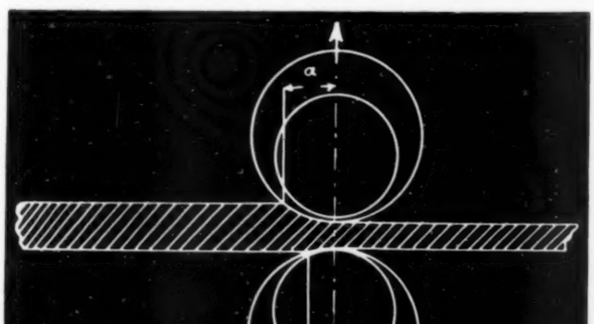
Cold-rolling strip in a cluster mill at the works of Arthur Lee & Sons, Ltd.

Rolling Pressure

The chief factor influencing the reduction with a given rolling pressure and a given power consumption is the diameter of the rolls. For the larger pair of rolls, shown in Fig. 3, the horizontal projection of the line of contact between the rolls and strip equals distance A and distance B for the smaller rolls. As a rough guide, the rolling pressure is the product of distance A or B multiplied by the width of the strip multiplied by the mean crushing strength of the steel being rolled. As already mentioned, the work consumed by friction accounts for a substantial share of the total power consumption; it being proportional to the rolling pressure, it will also be proportional to distance A and B. Hence it is obvious that with small rolls, the total power consumption will be much less than with large rolls.

In practice, the following rule will be observed in rolling :—

Fig. 3.—Showing the lines of pressure, using a large pair of rolls



Gauge : $\frac{3}{16}$ in. to $\frac{1}{16}$ in. diameter of roll in width.
$\frac{1}{16}$ in. to $\frac{1}{64}$ in. half diameter of roll in width.
$\frac{1}{64}$ in. to $\frac{5}{1000}$ in. third diameter of roll in width.

The diameter of a two-high mill increases in proportion to the width of the strip, but the arc of contact also increases and is equal to radius of roll multiplied by total reduction. Taking, for example, a rimming quality steel, the crushing strength of which will be approximately 100,000 lb. per sq. in. each pass up to 50% reduction, increasing it to about 140,000 lb. per sq. in. The reduction being approximately 33, 27, 20, and 15% at each pass, the pressure on strip 10 in. wide commencing at 10-gauge, between 10 in. diameter rolls, works out at 380,000 lb., and with strip 50 in. wide on 40 in. diameter rolls, the pressure is nearly 4,000,000 lb. Thus, for the same percentage reduction, increasing the width five times increases the pressure ten times, the pressure per inch of width being doubled. Rolling pressures in excess of 1,000,000 lb. necessitating rolls of 20 in. diameter and upward are not practicable with two-high mills, the work being more conveniently carried out on a backed-up mill.

Cluster and Four-High Mills

Backed-up mills possess individual advantages; one of the principles in the cluster mill being the absence of bearings on the working rolls. The roller does not experience the difficulty which many four-high operatives experience, due to end thrust when the working rolls become crossed. The working rolls can also be more easily changed and automatically align themselves when placed in contact with the backing rolls, eliminating the human element in lining up the mill, and incidentally a considerable saving in time is effected. The contact pressure between the working and supporting rolls is approximately 30% less per sq. in. of face on this mill as compared with the two-high. The working rolls being supported in both directions of force, smaller diameter rolls can be used to accomplish the same work. With backing-up rolls, having a ratio to the working rolls of 2 to 1, the cluster mill has approximately 40% greater capacity than a given two-high mill. In many four-high mills there is great difficulty in

holding the working rolls in alignment, the top baby roll being slightly staggered, the full backing effect being obtained when the strip enters the mill.

The working rolls of the latest mills are fitted with automatic centering devices, which, once adjusted, will always bring the top roll into a dead centre position. The roller bearings of the backing rolls on either cluster or four-high mills, should be rather ample, as their life is in inverse proportion to the third power of the load. With a given rolling pressure, this means that the life can be increased eight times through doubling the load capacity. High- or low-pressure systems cannot be employed with advantage in these mills. Adjustment of rolls in the larger cluster and four-high mills requires the application of power to the screws. The two principle reasons which recommend the four-high mill are, first, its simplicity and accessibility, and second, its arrangement removes all limitations as to backing roll diameter and bearing dimensions.

In the cluster mill the two backing rolls applied to each working roll must be placed as close together as possible,

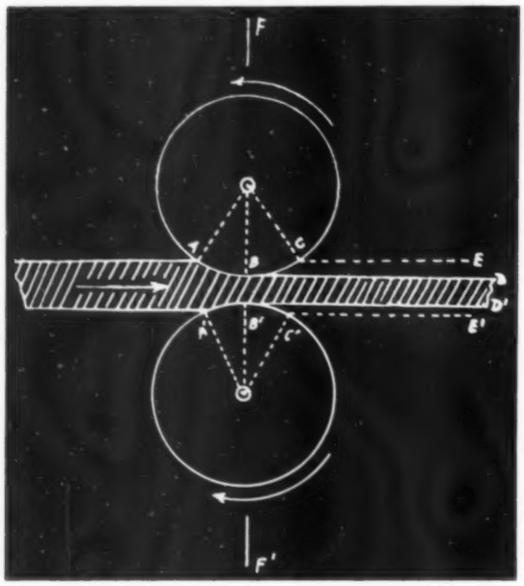


Fig. 4.—Showing the principle of rolling.

practically in contact, and in practice must not be more than about twice the diameter of the working roll. If these conditions are not maintained, the working rolls are so completely surrounded by the backing rolls that insufficient operating space remains. In the four-high mill there is no limiting condition, and any suitable ratio of roll diameter may be used. The fact that two rolls are used on the cluster mill where only one is possible in the four-high naturally reduces the size of the backing roll necessary to produce a given stiffness, but this effect is not so great as may appear.

The flexure of a roll varies inversely as the fourth power of its diameter in consequence of which the single roll of a four-high mill need have only 20% greater diameter than each of the two rolls of the cluster mill, to give equal stiffness. But the possibility of unlimited stiffness of the backing roll is not the most important advantage of the four-high mill. It is the freedom to use necks and bearings of unlimited size that most strongly recommends this design, whereas in the cluster mill there are quite definite structural limitations. Again, one must allow for the use of two bearings in the cluster mill to take the place of one in the four-high, but the angular forces produced by the cluster arrangement partially nullifies this advantage and requires that each bearing of this mill shall sustain about 70% of the load imposed upon the single bearing of a four-high mill under identical conditions.

The modern mill usually being composed of a train of three or four stands, the draughts at each pass will be regulated in accordance with the crushing strength of the steel and to maintain the same pressures throughout the mill, each stand working up to the capacity of its motive power and within approximately 5% of the overload allowed for peak fluctuations.

Principle of Rolling

Except for a slight lateral spreading, the strip is reduced in section and increased in length in proportion to the reduction. This is illustrated in Fig. 4. Let O A C and O′ A′ C′ be two motionless rolls which are being forced into the steel A A′ and E E′ by means of pressure applied vertically from F. The force exerted by the resistance of the strip will act along radii of rolls, as O A, O C, O′ A′. The resultant of all these forces will be in the vertical lines O B and O′ B′. Vertical compression of the steel will, however, only take place between the points B and B′. At all other points between A C and A′ C′ the strip is forced away from the rolls and is therefore elongated.

If, now, the rolls are made to revolve, the strip is reduced in size and elongation as at A A′ and D D′. This turning of the rolls introduces a second force which acts in the direction of tangents to the arcs A B and A′ B′, and is equal to the force of friction, and therefore proportional to the pressure between the rolls and the strip. The result of this force is to subject the strip to a longitudinal pull in the direction of B to D, the pull being at its maximum at A. The compression, however, is at its minimum at A and its maximum at B. The net result of this double action is to cause the strip to flow forwards at a higher velocity than the peripheral speed of the rolls.

Effect of Speed

The faster a piece of steel is rolled or deformed, the less time the molecules have in which to adapt themselves to the deformation, and the greater their resistance to this deformation. Consequently the stretching effect increases in undue proportion to the compression. If the speed of the rolls were sufficiently increased, they would have a greater tendency to slip on the strip, and the stretching effect would tend to become a tearing effect. It is, therefore, not the lineal speed through the rolls, but the rate of displacement which effects the resistance of the metal. The maximum rate of deformation is expressed thus :—

$$\frac{A\, r\, T2}{T1} = \text{Tan}\ \theta \text{ in. per second.}$$

where A = angular velocity of the rolls in radians per second ; r = roll radius in inches ; T2 = thickness after pass ; T1 = thickness before pass ; θ = angle of contact arc.

Draughts

The difference in sectional area between one pass and the next succeeding one is usually expressed in per cent., and while there are cases where as high as 50% reduction occurs in a single pass, the draught will seldom exceed 35% at the first pass on a 2-high mill. These heavy draughts take place at the first stand, and at the finishing stand will seldom exceed 15%. The width of the strip controls the draughts, and these in turn are controlled by the elements of the steel being rolled. Apart from these features the desire to improve output acts as an incentive to increase both the speed and the draught to the limit the mills will stand. There are many considerations, however, that operate to limit speed and draught below that which will do injury both to the steel and the mills. One of these is the additional power required for very rapid reduction ; another is the severe strain on the rolls and other machinery when the strip enters the mill at high speed and with large draught. Depending on the roll diameter and the gauge, the magnitude of draught may be restricted by the limit angle of the rolls.

Spread in Rolling

The amount of lateral spread depends upon many factors, but mainly upon the carbon content; the less the width of the strip in relation to roll diameter the greater the reduction per pass. In rolling narrow strip, say, 6 in. wide, the total spread, up to 50% reduction, may be 2% of the width. On the other hand, the spread on a high tensile steel, when given a 12% reduction, may be equivalent to the reduction of that pass.

Spread, as spread, is of little consequence to the width, as it is usually sheared or slit. It is, however, a deciding factor in elongation and is the one which governs the amount of curve or sinuousness when the strip is slit into multiple widths.

Fig. 5 shows a strip divided into vertical lamina of negligible width, which is subjected to a pressure F exerted by the rolls over the surface and in contact. The main effect, as has already been explained, is to cause elongation at right angles to the axis. The frictional forces set up by rotation, $P = F\mu$, where μ is the coefficient of friction between the rolls and the surface in content.

Spreading is opposed by the friction between the rolls and strip, this frictional resistance acting in the direction at right angles to A B, shown by the arrows. The extreme lamina 1 at C and D may be assumed to spread freely to the right and left respectively, but the next element 2, in spreading, is obliged to move the preceding lamina 1 against opposing friction, and so on until the layers 10 on either side of the centre line A B have to overcome the resistance caused by all the lamina between them and the edges of the section at C and D, the opposing force being $\frac{F\mu}{2}$ and as the total pressure F is necessarily increased with any increase in the width of the section, it is clear that the width may be conveniently—or, rather, conceivably—increased to such an extent that the frictional resistance to spread is sufficient to prevent any widening of the innermost lamina. The tendency to spread unequally across the section has a most important influence on the rolling of strip, for with unequal spread unequal elongation will result, and maximum elongation will correspond to minimum spread and will occur on the centre line A B of the section. The rate of elongation decreases from this line outwards until it reaches a minimum at C and D, where spreading of each unit of width is greatest. As the tensile increases, spread becomes greater.

The effect of spreading is shown in the micrograph (Fig. 7); it will be noted that the flow of the structure near the edge follows the line of a curve. Owing to this lateral axial elongation and lack of ductility, cracks have developed on the edges. As a result of this spread the strip possesses a barrel shape (Fig. 6), which is generally attributed to the flexure of the rolls. This view is mostly incorrect, although deflection will aggravate the fault. The condition arises on backed-up mills, where deflection of the working rolls cannot take place. In the case of 2-high mills, the remedy is to use cambered rolls. This has the effect of causing spread to take place with greater uniformity across the section.

The Effect of Cold-rolling and the Influence of the Elements

Cold-rolling compresses the structure into a state of permanent strain or distortion, and one in which the properties are considerably affected. The extent of this change varies according to chemical composition and the amount of reduction. Owing to the binding together of the crystals, the steel, due to its lack of molecular energy, prevents any readjustment of the grains, and cannot be economically worked after 50% reduction. In the case of high carbon and stainless steels, which work-harden more rapidly, the degree of reduction will necessarily be less. Carbon is the controlling element in regulating the physical properties, and is capable of changing most of these properties. The most important influence is connected

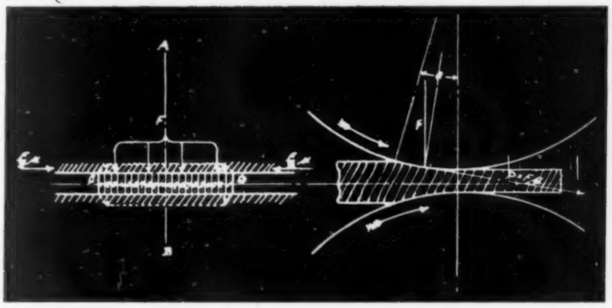


Fig. 5.—Lateral spread of strip shown diagrammatically.

Fig. 6.—Shape of rolled strip due to spread.

with the hardness, strength, and ductility. Its effect on these properties are varied in extent by cold rolling. Each 0·1% added up to 0·9%, increasing the yield-point 1·8/2 tons, maximum strength 4 tons, elongation is reduced 6/8% and the area of reduction decreases 7%.

Phosphorus.—When up to 0·10% phosphorus produces brittleness to a degree that is very harmful, by inducing cold shortness. For practical purposes the phosphorus content of steels for cold-rolling should not exceed 0·04%. The tensile strength is increased approximately 0·5 tons for each increase of 0·01%.

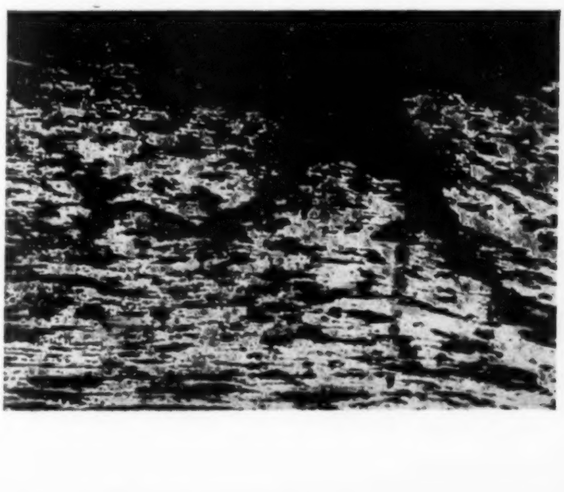
Manganese.—Up to certain amounts, varying with conditions and use of the steel, manganese is wholly beneficial. It adds somewhat to the tensile strength, the beneficial effects depending upon the carbon content. Above 1·0% it produces undue hardness and brittleness, which becomes very marked as this point is passed. In cold-rolled steels the content should not exceed 0·50/0·60%.

Sulphur.—The effect of sulphur upon the tenacity and ductility of steel at least up to 0·6% is very slight. In the form of ferrous sulphide it is capable of doing great harm, but when neutralised with manganese in sufficient amount it may be comparatively harmless. This element, however, should not exceed 0·05% in cold-rolled steels.

Silicon.—Owing to the fact that all but traces of silicon may be removed in any and all of the processes for manufacturing steel, its effect need not be considered. When rolling spring strip it will be found that steel with the silicon content ranging from 0·25 to 0·35% has greater resiliency than steels of low silicon content, and without increasing brittleness.

(*To be continued.*)

Fig. 7.—A micrograph showing the effect of spreading.



Improvements and Developments in Methods for Seamless Tube Manufacture

A development in tube manufacture is described which is claimed to eliminate the pounding and hammering of the metal by a steady and gradual pressure.

IN engineering circles great interest is attached to a recent development associated with the manufacture of ferrous and non-ferrous seamless tubes, which is covered by the British patent number 447,988. The interest shown is probably as great as that taken in the methods of P. A. Foren, for which British patent number 393,636 was granted.

There is a similarity in the products of both these systems inasmuch as the operations effect considerable reduction of the outer diameter and wall thickness of the tubes being processed. In addition, the pierced billet or hollow shell under operation in Foren's design, which was first applied in the United States of America, effects a small reduction in the bore. The pierced billet or hollow shell is threaded on to a long solid mandrel bar, on which it is an easy fit, and is passed through rolls arranged in series. During the threading process the rolls acting on the external diameter, in conjunction with the mandrel governing the ultimate bore, reduce the outside diameter, at the same time effecting reduction of the wall thickness.

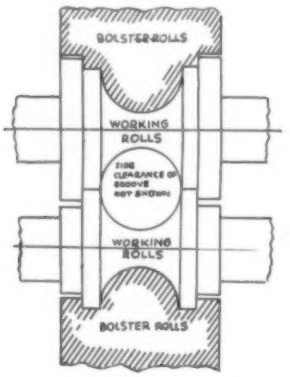


Fig. 1.

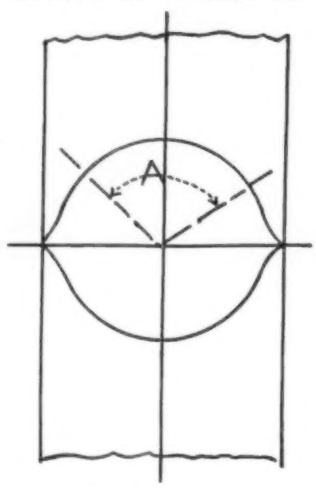


Fig. 2.

Fig. 1.—*Bolster rolls used to support the actual working rolls.*

Fig. 2.—*Showing the design of the working rolls.*

The rolls are arranged generally in series, in pairs, in sets of six, and each pair of rolls are designed to give pressure on the hollow billet covering part of its external circumference, so that, in its completed passage through the process, the whole of the external and internal surfaces have been subjected to the reducing action of the rolls, which, with the pairs starting vertically, and the second pair horizontal, contact with the four remaining rolls which are arranged at various angles to the working centre of the mill.

The grooves in the working rolls are of a non-circular section, so that, as stated, a comparatively small section of the hollow is kneaded or reduced by each pair, and so on until the whole diameter of the hollow has been subjected to the combined action of the rolls and mandrel. The grooves, however, in the final pair of rolls are perfect half circles, forming the complete circle to which the outside diameter is reduced.

In Foren's design of mill the first and second pair of rolls are direct driven, the third pair being operated by the action of the first and second on the blank, the fourth and fifth pair are also direct driven, as is also the final pair, which impart perfect circularity to the finished tube. In the new design, specification 477,988, the rolls and mandrel in conjunction provide the reducing action, the propelling force during the operation being obtained either on a push bench by means of hydraulic power, by a rack and pinion, or by a chain bench of the well-known endless-chain type. None of the rolls are direct driven, as in the case of the Foren mill, but are arranged in similar series.

An outstanding feature of the patent under review is that support or bolster rolls are included, somewhat similar to the arrangement of cluster mills as applied in the rolling of sheets, strips, and the like. This arrangement allows the actual working rolls to be of comparatively small diameter, and the supporting rolls of large diameter, as shown in Fig. 1. In order to eliminate side thrust on the working rolls, the necks of these are provided with roller or similar type of thrust bearing. While an ingenious arrangement of holding-down screws, which operate simultaneously on both necks of the working rolls ensures perfect alignment of the grooves in the periphery of the working rolls.

This section of the mill consists of a central worm operated by a hand-wheel, which engages two worm-wheels keyed to the top of the thrust, adjusting spindles bearing on the chocks in which the necks of the working rolls are carried. The supporting rolls are of relatively large diameter in comparison with the working rolls; they are designed with an armular projection which fits closely in the groove and on the body of the working rolls, thus imparting rigidity and effecting perfect alignment throughout the series. A sectional view, through the working grooves of the operating rolls, shows that this is designed on the principle of the Pilger or step-by-step method of rolling tubes, Fig. 2, there being sufficient side clearance to eliminate the possibility of pinching the metal during its progress through the reducing operation.

Claims are made, based on long practical experience, that the method adopted entirely eliminates the great friction and wear and tear of drawing tools—mandrel and die—which exist in cold-drawing by push-and-pull benches, and reduces the number of cold or hot passes necessary to arrive at a desired diameter and thickness. As a purely hypothetical example, the hollow shell as subjected to the first and second pairs of rolls may be 2 in. outside diameter and $\frac{5}{16}$ in. thick, and in its passage through the third and fourth pairs of rolls may be reduced to $1\frac{7}{8}$ in. $\times$ $\frac{1}{4}$ in., and so on until the required outside diameter and wall thickness has been attained. Little reduction of internal diameter is made, this being governed by the difference of the bore of the original pierced shell and the solid interior mandrel.

In its application to either the push or chain-bench processes of drawing, one outstanding feature in comparison with the Foren process is that in no case are either pair of working rolls power-driven, the reducing of the sectional area of the tube is due to the frictional contact between the rolls and the hollow shell. To effect a similar result by the generally accepted cold-drawing operations, it would be necessary to employ a series of passes on a push-or-pull bench, between each of which it is necessary to anneal and pickle the tube, on account of the hardness imparted during the actual drawing. To the practical tube makers it will be obvious that this new departure in hot-or cold-drawing, the pounding and hammering to which the hollow shell is subjected in other methods is entirely eliminated by the steady and gradual pressure exerted by this new development.

Some Measurements in the Yield-point Range of Mild Steel

By G. WELTER
(Department of Metallurgy, Warsaw Polytechnic.)

The phenomena at the yield point of mild steel is investigated more fully by means of a special test equipment, permitting of direct reading of the load and elongation of the test-bar. Tests were carried out with a rigid and flexible suspension of the test-bar, partly under control of the results by the usual equipment of the actual machine on the basis of a uniform time-scale in order to determine the influence of the dynamometer masses of the usual machine, and that of the yield velocities of the material; also, it was important to ascertain what reaction is caused by the elongation of the test-bar upon the dynamometer readings. The results show that the moving masses of the dynamometer do not vitally affect the shape of the stress-elongation diagram, but that, on the other hand, the yielding of the test-bar is apt to have a considerable influence upon the readings and records of machines with a high-leverage ratio.

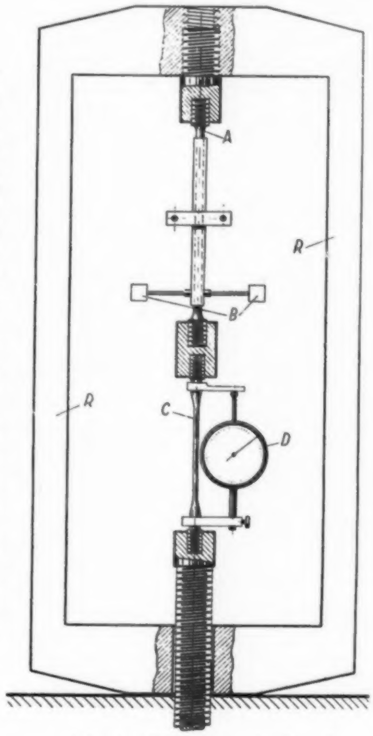


Fig. 1.—Diagrammatic view of test equipment.

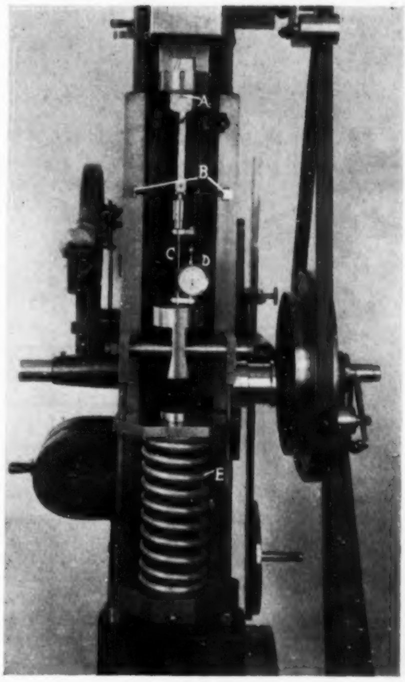


Fig. 2.—The arrangement incorporated in an Amsler Machine.

THE phenomena at the yield point of mild steel, which is known to show an abnormal behaviour compared with other metals and alloys, in so far as the load on the usual tensile machine suddenly drops off considerably after passing an upper limit, have not as yet been fully cleared up; it has not yet been definitely established whether, and to what extent, the test equipment is without influence upon the results secured. It is more especially the dynamometer masses of the machine, and the yield velocities of the test material which are likely to provide sources of error.

In order to eliminate these two factors as far as possible, while carrying out the test, or at least to provide a check over them, the following experiments were carried out.

Performance of Test

On the 5-ton Amsler machine used for this kind of tests, with a load range for 500 kilogs. and pendulum dynamometer, mild steel test-pieces (0·07% C.) of 3·5 mm. diameter were tested by reading the load direct off the test-piece by means of a special dynamometer of as little mass as possible. To one end an elastic force indicator was incorporated between test-bar and the upper clamping head of the machine, on the principle of the control bar, and the particular load determined on the basis of purely elastic deformations of that control bar by means of the Marten's mirror instrument on a scale with a telescope.

In order to obtain as accurate results as possible of the maximum loads of 300 to 400 kilogs. entering into consideration, modified duralumin was used as a control bar which shows approximately three times greater deformations than steel within the elastic range. This dynamometer, which comprises a weight of only approximately 37 grms. of the test-bar, and which moves only very small distances before the maximum load is reached (approximately one-tenth of a millimeter), may be considered perfectly free from mass compared with the usual dynamometers, and without dynamic reactions due to the moving masses upon the test. By means of this precaution the question of mass effects of the pendulum dynamometer, which falsify the measurements due to relatively large path distances, could be considered more fully.

Further, in order to subject the yield distances of the test-bar, in the range of the yield limit, to accurate control, the deformations were determined from the test-bar direct by means of a micrometer permitting of a measurement of total elongation of 10 mm., by readings of 0·01 mm.

In addition, the yield velocity, which has already been discussed in detail,[1] is also a factor of considerable importance on the test results, and measurements were taken during the test on the basis of a time factor. To one end the specimens were loaded slowly and uniformly, and the changes of load determined in regular, preferably short-time intervals on the test-bar, both in the elastic and in the plastic deformation range, until the yield point was passed.

[1] G. Welter, *Metallwirtschaft*, No. 38. P. 885. Sept., 1936.

In this way a series of testing possibilities were afforded on the basis of which a certain clarification of the fairly complex conditions at the yield point, when testing mild steel, was rendered possible. The test equipment, depicted diagrammatically in Fig. 1, enabled accurate measurements to be taken under the following test conditions:

(*a*) Perfectly stiff, inflexible loading device for specimen "C." The latter is incorporated perfectly rigidly in a stout frame "R" (Fig. 1), and can be influenced, apart from its own elastic deformation, only by the exceedingly negligible elastic deformation of the bar dynamometer, which under a load of approximately 300 kilogs. in the range of the yield point only shows a longitudinal variation of approximately 0·1 mm.

(*b*) A semi-rigid load, by interposing the pendulum dynamometer of the machine (which is adhered to in case "A"), thus permitting of checking up the results by the machine diagram.

(*c*) A perfectly elastic load, interposing direct between lower head of the test-bar and the loading device of the machine a yielding intermediate link in the form of a helical spring.[2] In this case again the work was carried out with, and without, the pendulum dynamometer engaged, and a diagram recorded by the machine.

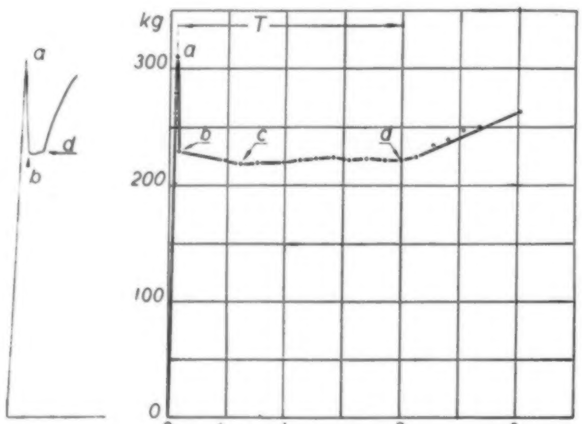


Fig. 3.—Diagram recorded by the machine together with the stress-elongation diagram.

In Fig. 2 an arrangement is reproduced as incorporated in the Amsler machine (with a helical spring introduced). The control bar dynamometer "A," with Marten's mirror instrument "B," is fixed to the upper fixed clamping head of the machine, while at the lower end of the control bar the test-bar "C," with micrometer "D," was directly attached.

By cutting out the pendulum dynamometer of the machine (which was effected simply by preventing the pendulum from moving), and also by fitting or removing the helical spring "E," the tests can be carried out under the given types of loading *a—c*. The test results are reproduced in Figs. 3 to 6.

Test Results [3]

(*a*) *Normal Working Conditions of the Machine.*—After checking up the test material to determine whether a distinct yield point was present, trials were carried out, the first test series being under the normal working conditions of the machine. The test-bar, together with the control bar dynamometer (as per Figs. 1—2), were slowly loaded with the pendulum dynamometer free to move, and the tensile diagram was recorded by the machine, and the readings of the micrometer also the mirror instrument of the control bar, were taken every 10 secs. The diagram recorded by the machine, which was taken only in the region of the yield limit, is given in Fig. 3, together with the stress-elongation diagram recorded on the basis of the time factor by direct reading of the control-bar dynamometer and micrometer.

It will be seen from this illustration that the two diagrams tally very well with one another, both with regard to shape and also numerical values. A conspicuous feature is that in the machine diagram the drop of load from the upper to the lower yield limits occurs very suddenly (fraction of a second) and drops immediately to the lowest point *b*, whereas the elastic control-bar dynamometer likewise indicates a very heavy drop *a—b* (Fig. 3, right hand), although it does not immediately drop to the lowest point at *c* but only to *b*, whence it reaches the point *c* in approximately 20 secs. The entire yield duration *t* amounted to approximately 120 secs. (*a—d*), during which time the bar extended to approximately 2 mm.

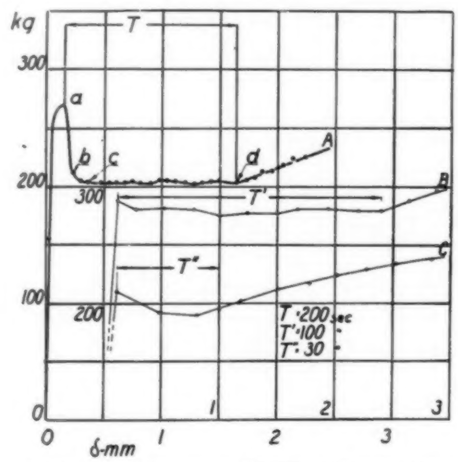


Fig. 4.—Load-elongation diagram with pendulum dynamometer out of action.

(*b*) *Fixed Pendulum Dynamometer, Rigid Fixing.*—If the pendulum dynamometer on the tensile machine is put out of action, and, necessarily, also the recording device for taking the machine diagram, a load-elongation diagram, as represented in Fig. 4, will be obtained by means of control bar and micrometer. This diagram indicates a smaller maximum load *a* at the yield point, and in addition the drop *a—b* from the apex is not as steep as in the preceding case, which may possibly be attributable to hazards in the formation of the yield limit, which may differ from one specimen to another; also, the further drop in load *b—c* to the lowest point proceeds gradually. The entire flow duration "T" amounted in this case to approximately 200 secs., and the text-bar extended by approximately 1·65 mm. These differences may be due partly to the differences in the elongation speeds produced by hand, by crank drive, which, although produced very slowly and evenly, could not always be maintained in exactly the same measure. In two other cases the diagrams "B" and "C," Fig. 4, were obtained with this arrangement.

(*c*) *Elastic Loading with Pendulum Dynamometer.*—In this type of loading, effected by interposing a spring "E" (Fig. 2), the diagram recorded by the machine takes an entirely different course; the usual one with upper and lower yield point[4] is known. The load increases regularly until the first bends away from the straight occur in the diagram, Fig. 5, on the left, which develop quite gradually while the bond terminates at *b* when the curve rises gradually and steadily while the increase in load takes

2 The intermediate link must be incorporated entirely without friction between test-bar and loading device, as otherwise erroneous results will be obtained due to friction; in the event of any minor friction occurring, the test-bar will not yield towards the side of the spiral spring, but towards the opposite side of the dynamometer, and with the machines of great leverage ratio this will give the illusion of heavy drop in load.

3 The above tests have been effectually supported by S. Gockowski, to whom I desire to express my thanks.

4 Wiad. Inst.Met.Rok. 3. No. 1, str. 33, *Metallwirtschaft.* No. 38. P. 888. Sept., 1936.

place steeply, again against small increments in elongation. The stress-elongation diagram, recorded according to time. of the control-bar dynamometer and of the micrometer (Fig. 5) on the right, takes a course similar to that taken by the machine, inasmuch as the curve, first of all, gradually bends away from the straight (a—b), and then yields a little faster at b—c, correspondingly to the section

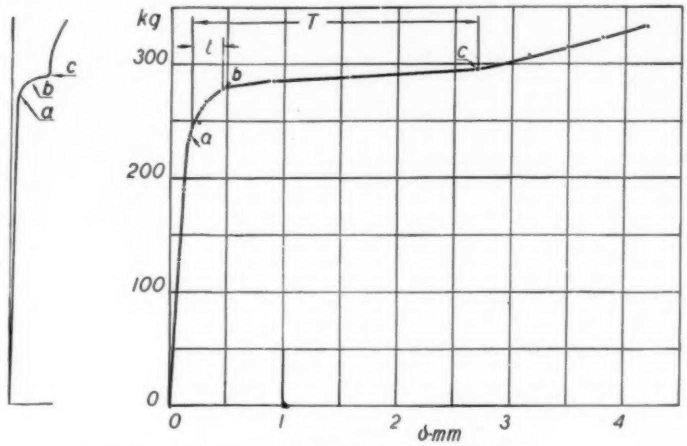


Fig. 5.—Stress-elongation diagram of the control bar dynamometer and of the micrometer.

b—c of the machine diagram, while steadily rising, terminating at c. The formation of the bend a—b at the elongation velocities under consideration (which was difficult to adjust to the preceding test speeds, due to the helical spring being interposed, took approximately 40 secs., while the centre yield performance in the range of the yield point took approximately 70 secs. Here again, the steadily rising course of the tection b—c at the yield point, as obtained in all diagrams with the spring load, is clearly in evidence.

(*d*) *Elastic Loading without Pendulum Dynamometer.*—Elastic loading, with interposed helical spring as per Fig. 2, gave approximately the same results, though with fixed pendulum dynamometer of the machines. Here again, the shaping of the load-elongation diagram at the yield limit (Fig. 6) is substantially the same as in the previous diagram, Fig. 5, on the right. The development of the bend a—b occurred here is somewhat shorter time (approximately 20 secs.), whereas the remaining course b—c took about double the time (40 secs.). According to the load-elongation velocities, the section a—c may, of course, be traversed considerably more slowly, without affecting the essential character—that is, the steadily rising course of load elongation, as has been shown.

Conclusions

From the test results under consideration it is evident that the masses of the pendulum dynamometer of the test machines do not exert vital influence upon the course of the stress-elongation diagram, at least not to any appreciable extent as far as the loading speeds here applied are concerned. It has been possible to ascertain that it is immaterial whether the pendulum dynamometer is engaged or cut out; in both cases approximately analogous results were obtained for the stress-elongation diagram.

The drop from the upper to the lower yield point occurs very rapidly, which is equally indicated by the control-bar dynamometer, where the material continues to yield at approximately the same load. No material differences between the diagrams with and without the pendulum dynamometer interposed have been traced. On the other hand, the diagram obtained by interposing a spring between the lower clamping head of the test-bar and the machine drive shows an entirely different course. In this case it is not an upper and then a lower yield point that is determined, but, as is more natural, the lower yield point appears first at which the material slowly begins to flow; not until then does the upper yield point become apparent, after the yielding capacity at the yield limit, which takes place under increasing load, is exhausted before the material elongates more slowly again with respect to the load. In this type of test also no appreciable difference was to be

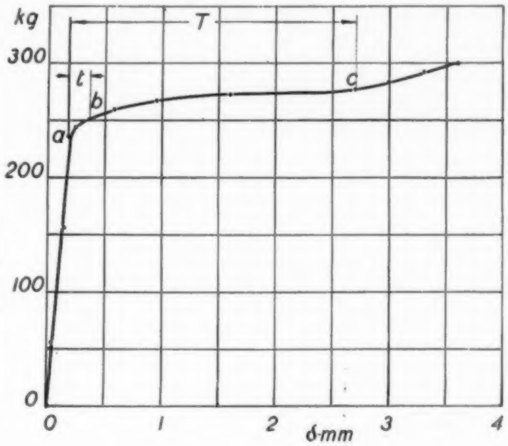


Fig. 6.—Load elongation diagram at the yield limit.

found in the diagram when the pendulum dynanometer was incorporated or cut out.

Contrary to the yielding process in the usual arrangement of the machine, which occurs very quickly from the upper to the lower yield point, and which may be styled a dynamic process, owing to the distinct accelerations observed, such a sudden flow process is not observed in the test with elastic suspension. Although the material elongates more quickly in the range of the yield limit than is the case previously—viz., proportional to the increase in load,—in no case could a sudden elongation be noticed without increase in load which might permit of inferring an upper and lower yield point on the former lines. If the test-bar thus, under rigid loading, has occasion to extend, as it were, into the force measuring equipment, this is almost invariably attended by a drop in load. But where opportunity is provided for the test to extend into a flexible intermediate link, such, for instance, as is the case where a spring is interposed, no drop in load from an upper to a lower yield point will become evident; on the contrary, a lower yield point will first develop in the very opposite order of sequence, followed by a higher yield limit within the yield range of mild steel.

Sands, Clays and Minerals

THE recent issue of the above publication is well up to the standard of previous issues and includes articles on a wide range of subjects. Of special interest is an article by Mr. A. H. A. Robinson, Department of Mines, Ottawa, on "Nickel in Canada," but the issue contains many informative articles on such subjects as :—Pure Silica Sand as a Basis for Phosphate Deficiency Test; Mineral Resources of Brazil; The Application of Titanium Oxide; Boron; Soils; Industrial Water Supply; The Barytes Deposits of Greece; Precious Metals; Use of Fire Cement; Mining and Mineral Resources of Tanganyika Territory; Moulding-Sand Tests, etc.

Published by A. L. CURTIS, P.O. Box 61, Chatteris, Cambridge, England. Price, 3s. 6d.

Stewarts and Lloyds, Ltd., Glasgow, have received a contract for the supply of 36 in., 30 in., and 24 in. cast-iron or steel bitumen-lined pipes, valued at £22,402, from the Stirlingshire and Falkirk Water Board, Falkirk.

Metallurgical Problems in the Chemical Industry

Metallurgical developments in recent years have contributed much to progress in the chemical industry, and in a recent lecture before the Midland Metallurgical Societies, Dr. N. P. Inglis discussed some of the problems encountered in this industry, which have involved considerable metallurgical research, the salient features of which are given in the following article.

IN recent years the chemical industry has been rendered a great deal of assistance in connection with corrosion problems by the development of a large series of corrosion-resisting steels; there are, in fact, chemical plants now at work which could not have been built had it not been for the metallurgical development in this field. The word "stainless," which is used so much in connection with certain steels, is now almost meaningless, and to describe a steel as a stainless steel is entirely inadequate. The original steels in this class contained from 12 to 14% of chromium, with a carbon content of 0·30 to 0·40%. This carbon content rendered it impossible to fabricate the material into many of the forms required by the chemical industry, and consequently the development of low carbon chromium steels, known as chromium irons, proved a very great boon to the chemical industry.

There were, however, difficulties associated with the welding of these irons, and for chemical work the material was generally used in the riveted form. From this class of materials the major developments took the form of the addition of nickel, and a class of corrosion-resistant steel now used to a large extent in the chemical industry contains between 12 to 20% of chromium, and 8 to 15% of nickel as the main basis of the composition. The carbon content is usually less than 0·15%, and the steel may contain other alloying elements depending upon the particular corrosive medium which it is called upon to resist. The chief obstacle in the use of this steel in the early stages of its development was the fact that the properties of the steel were seriously affected when it was heated in the range 500° to 900° C. After the steel had been heated in this range, the precipitation of chromium carbide from the normal solid solution took place. These precipitated carbides took the form of a grain boundary film, and when the steel was placed in many corrosive media, disintegration of the steel resulted because of the grain boundary attack. This peculiar feature had become known as "weld decay," but it really had nothing to do with anything which took place in the welding of the metal.

Various attempts have been made to overcome this particular defect, and Dr. Inglis dealt first with the reduction of the carbon content, pointing out that for many corrosive conditions this was quite effective, but it could not be regarded as a general solution of the problem, unless the carbon content was reduced to an impractically low figure. Other developments in this direction take the form of the addition of various alloying elements, and of these it has been found that the addition of titanium is very effective. He emphasised the importance of the correct ratio of titanium to carbon in order that the full benefit of the former element should be realised. He also emphasised that other elements could be used; in America it had been stated that columbium had an equally beneficial effect. A difficulty with titanium-bearing alloys is in the welding of this material—a problem arising due to the loss of titanium in the weld metal itself.

Referring to the question of the strength and stability of steels at the moderately high temperatures of 350° to 550° C., Dr. Inglis mentioned the principal requirements of such steels. These requirements consisted of good strength at the required temperature—that is to say, a small rate of creep under as high a stress as possible, with no reduction of the properties after long exposure to these temperatures, and also any such steels must present no unusual difficulties to the manufacturer. The problem of design of plant at elevated temperatures was rather different from that involved where design at room temperatures were concerned. Dr. Bailey had recently evolved a rational basis of design when creep conditions were involved. Among some of the more important results which had been obtained from creep tests carried out by a large number of investigators, was the beneficial influence of molybdenum, and the effect of the addition of chromium, in which latter case it has been found that up to 1% of chromium gave a big improvement in the creep properties.

With reference to steels for use at very high temperatures up to 1,000° C., mention was made of the beneficial influence of additions of chromium in reducing attack by oxidising and sulphur-bearing gases, but the fabrication of chromium steels of high chromium content presents some difficulties, and the introduction of nickel into the steel gave some help in this direction. It has been found that the addition of nickel to a high chromium steel improves the strength at these very high temperatures, and also increased the workability of the steel.

Discussion

Dr. J. W. Jenkin referred to the possibility of making corrosion-resistant steels in the open-hearth furnace by the direct-reduction method. Dr. Inglis stated that the manufacture of these steels by such a method did not seem to have made very great strides, and he referred to the danger of chromic oxide in the steel if it were made in the open-hearth furnace by the direct-reduction method.

Mr. J. V. Murray asked for information regarding the life of a steel containing about 25% chromium, about 20% nickel, and about 2% of silicon, and wondered whether such a steel would end its life by oxidation or by intercrystalline corrosion. Dr. Inglis pointed out that even if grain boundary carbide precipitation did occur in such a steel, it did not necessarily follow that failure was inevitable, as this would depend upon the surrounding media. He considered, therefore, that the steel mentioned by Mr. Murray would ultimately fail by oxidation, but he considered that at, say, 1,000° C., this steel would have an extremely long life provided true oxidising conditions were maintained throughout its life.

Replying to a question by Mr. J. T. Wright, Dr. Inglis did not think the addition of titanium to the chromium-nickel austenitic steels could be relied upon to give any appreciable improvement as regards their creep characteristics at elevated temperatures. Mr. Wright had mentioned the formation of a ferrite phase in these chromium-nickel steels, but he would point out that other elements as well as titanium would cause the formation of the ferrite phase—for instance, silicon, vanadium, and molybdenum. Mr. Wright had also raised the question of the direct-reduction method for the production of these steels. Dr. Inglis again pointed out that the chemistry of this process clearly introduced dangers and difficulties, and in view of the known difficulties of fabricating these steels, one would hesitate to introduce the possibility of further difficulties. The question of the use of silicon as a means of inhibiting weld decay had also been raised, and he agreed that silicon was a useful element in this respect.

The Soviet Academy of Sciences

By A SPECIAL CONTRIBUTOR

The rapid industrial development of the U.S.S.R. is due in no small measure to the valuable work of the Soviet Academy of Sciences: to-day its role is to co-ordinate and to direct the whole of the scientific activity in the country, to guide research into fruitful channels, to speed up the application of scientific achievement in construction; generally, to create a scientific foundation for the whole national economic plan.

THE successful fulfilment of the first and second Five Year Plans (the second is now at the end of its fourth year), the near approach of the third Five Year Plan, as well as the rise of the Stakhanov movement, have all confronted the Academy of Sciences of the U.S.S.R. with many new and complex problems. How was the Academy to help the shaping of the third Five Year Plan? In what way could the Academy assist the movement for a higher productivity of labour? To understand the answers to these questions, it is necessary to know something about the history of the Academy and the immediate tasks it has to fulfil.

The Academy of Sciences was founded in 1725 by Peter the Great as an "assembly of the best learned men." They were not only to carry on research, but to train young scientists and to study the country's natural resources. As early as 1745 the Academy published the first geographical atlas of Russia. Under the old regime, the Academy devoted most of its energies to abstract research, surveys of natural resources, and the study of Asiatic languages. The character of the Academy's activities did not change immediately after the revolution. They remained out of touch with the actual needs of the country for some time. The change came in 1929. The function of the Academy was then defined as the direction of the whole volume of scientific knowledge towards the reconstruction of the national economy. A number of people distinguished in various branches of technological science were admitted to membership of the Academy, and a Council for the study of the natural resources of the U.S.S.R. was formed.

In 1934 the Academy of Sciences was made directly responsible to the Government of the U.S.S.R., and its headquarters were transferred from Leningrad to Moscow. The removal was made with a view to bringing the supreme scientific institution of the country into closer contact with central administrative bodies, particularly with the State Planning Commission. The Academy thus assumed the role of adviser and close collaborator in the drawing up of the unified economic plan for the whole country.

The Presidium of the Academy, its central administrative departments, its principal research institutes and laboratories, are now in Moscow, where immense new buildings are going up to house the various sections. Under its new constitution, adopted in November, 1935, the aims and functions of the Academy were defined thus: Firstly, uniting as it did all the leading scientists of the country, the Academy had not merely to become a centre for the passive registration of scientific fact; it had to become an active body for the development of scientific thought. Secondly, the Academy had to study and develop world scientific achievement with a view to applying the most modern scientific theory to practice in the work of construction. Thirdly, the Academy had systematically to utilise the achievements of Soviet and foreign science to further the country's progress.

The Technical Section of the Academy was charged with the duty of seeing that the results of research were introduced into industry. It had to maintain contact not only with the research institutes and laboratories of the Academy itself, but with the various commissariats and industrial enterprises. For this purpose the various institutes had to set up machinery through which they could keep in touch with the Technical Section of the Academy. Among the groups now functioning under the Technical Section are those dealing with power, mining, technical physics, technical chemistry, technical mechanics, automatic processes, and telemechanics.

The fourth function of the Academy was to study the natural resources and productive forces of the country, and to promote their rational utilisation. For a number of years, the Council for the study of the natural resources of the U.S.S.R. has been sending out expeditions for these very purposes. Branches of the Academy have been established in various parts of the country to direct the work of prospecting and surveying. The first preliminary general survey of the geological, chemical, and economic resources has already been completed.

Now, with the approach of the third Five Year Plan and its problems, the activities of the Academy in this field are to undergo a decided change. Attention will be concentrated on key positions. The number of the Academy's branches is to be reduced (branches are now maintained in Georgia, Azerbaijan, Armenia, Kazakhstan, Tajikistan, the Urals, the Far East, and the Kola Peninsula), and their function limited to the direction of research. During the past few years the minority republics have developed and trained efficient scientific personnel of their own. Some of the research institutes, now controlled by the Academy's branches, will be handed over to the local authorities. At the same time, closer contact will be maintained between central scientific bodies and the research institutes of outlying republics.

The scientific expeditions of the Academy of Sciences itself are already attacking their problems in a new way. To-day it is no longer a question of locating useful ores and registering their sites on a map. The Academy now has to determine the laws governing the distribution of mineral ores in the U.S.S.R. in order to conduct a rational research for new deposits, to determine their extent and industrial importance and to recommend the best way to exploit them on an industrial scale.

The fifth function of the Academy is to study the cultural and economic achievements of mankind and to render such help as it can in their rational application for the building up of the new society. The main responsibility for this work falls upon the Social Sciences Section, which has lately been strengthened. The problems with which the different institutes under this section have to deal are many. For example, the Institute of History is to make a special study of historical science, and the bodies which are to help in this study include the institutes of philosophy, economics, linguistics, ethnography, oriental studies, history of science and technique. Among the problems of philosophy, one of the most immediate is the philosophical analysis of physical and chemical theories on the structure of matter.

The new constitution of the U.S.S.R. has necessitated changes in the work of the Institute of Soviet Construction and Law. Some of its functions will be taken over by the All-Union Commissariat of Justice set up under the new constitution. The Institute of Literature in Leningrad, of which the late Maxim Gorky was the head, has now been merged with the Institute of World Literature in Moscow.

The work of the Academy in the immediate future is to aid the State Planning Commission in the drawing up of the third Five Year Plan. The main efforts of the Academy's various institutes will be directed towards the solution of ten specific problems, outlined at a session held last March. (Needless to say, these problems do not comprise the whole work of the Academy and its research workers, but, for the moment, they are the leading and dominant ones.) The ten key problems on which the Academy is to concentrate in connection with the third Five Year Plan are the following :—

1. To develop geological, geochemical, and geophysical methods of prospecting for useful minerals, particularly tin, rare metals, and oil.

2. To solve the problem of electric power transmission by creating, on a scientific basis, a unified electric power system throughout the U.S.S.R., with high voltage transmission.

3. To rationalise and extend the use of natural gas and by-product gas from industrial plants (although Soviet resources of natural gas are greater than those of the United States, extraction is one-fiftieth that of the latter country).

4. To find a new type of fuel for internal combustion engines (a study will be made of chain reactions and explosion processes, the internal combustion motor and electric automobiles).

5. To rationalise the technological processes in chemistry and metallurgy ; to work out scientific means for the better utilisation of equipment and increasing output.

6. To help attain Stalin's objective of raising the grain yield of the country from 7,000 million poods to 8,000 million poods (one pood equals 36 lb. avoirdupois) by laying the basis for a further increase in fertility. (This will involve research in seed selection, soil chemistry, plant biology, fertilisers, and the mechanisation of agriculture.)

7. To establish scientific bases for the development of animal husbandry and fisheries.

8. To develop telemechanics (long-distance control of machinery), and to extend automatic processes in industry through application of theoretical physics.

9. To draw up the balance-sheet of the national economy of the U.S.S.R. so as to serve as a scientific basis for the third Five Year Plan.

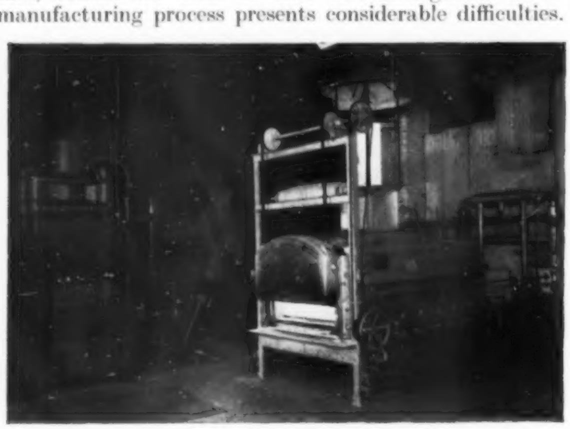
10. To study the history of the peoples of the U.S.S.R.

By its work on these ten leading problems, the Academy of Sciences will furnish the scientific foundations on which the State Planning Commission will build the unified plan for the national economy. As the supreme scientific body in the country, the Academy is charged with the duty of setting the general trend for research in accordance with the immediate and vital problems of the State, also with the function of co-ordinating the plans of the various research institutes with the general state plan. This does not mean that the Academy will attempt to lay down detailed programmes for its 40 research institutes and the 800 research institutes controlled by the different commissariats, nor that research will be confined to the ten problems enumerated. It does mean, however, that lesser problems will be subordinated to questions which are of vital need to the country as a whole.

The role of the Academy of Sciences of the U.S.S.R. is to co-ordinate and to direct the whole of the scientific activity in the country ; to guide research into fruitful channels ; to speed up the application of scientific achievement in construction ; in short, to create a scientific foundation for the whole national economic plan.

Gas Furnace for "Cladding" Steel

THE one real hindrance to the rapid development of the use of stainless and other special steels is their high cost. Therefore, any process which will produce materials with similar properties at less cost is bound to be interesting. Such a process is being developed by Mr. Gordon, and carried out by Spear and Jackson, Ltd., of Sheffield. The product is a composite sheet of mild steel faced with special steel or, for that matter, pure nickel or monel, and is known as "cladded steel." The general principle is not particularly novel, and is, in fact, almost the same as that of rolled gold : but the manufacturing process presents considerable difficulties.



Town gas-fired furnace used in the production of "cladded steels."

The most important of these is that scale on either of the components of the cladded sheet before pressing and rolling will lead to an imperfect bond between the two metals. Obviously it is not easy to heat any kind of steel to 1,300° C. without scaling. The difficulty has, however, been overcome by using the process developed by the Sheffield Gas Company for hardening high-speed steel tools without scaling or decarburising them. In this process the furnace muffle is purged with an atmosphere consisting of the products of partial combustion of town gas, which have been cooled (to condense out the water vapour), reheated and mixed with a controlled proportion of unburnt gas. By suitable control of the air/gas ratio in the burner, and of the proportion of unburnt gas in the muffle atmosphere, the oxidising and reducing components, as well as the carburising and decarburising components of the mixture, can be adjusted to balance one another for the particular steel being treated.

As a critical test a sheet of stainless steel, only 3½ thousandths of an inch thick, was heated at 1,150° C. for 5 mins. in the atmosphere-controlled furnace and afterwards rapidly cooled in air. After the test the sheet was still 3½ thousandths thick. Illustration shows the Brayshaw town gas-fired furnace used by Spear and Jackson, Ltd., in the production of their cladded steels. The muffle is 6 ft. 6 in. × 4 ft. × 2 ft. 6 in., and can be heated up to 1,400° C. Special burners are used with water-cooled nozzles, and burn partially premixed gas and air. The temperature is maintained by a standard electroflo automatic controller. At the left side of the illustration is the hydraulic press in which the slabs are pressed before rolling, and at the rear of the furnace is the atmosphere-producing unit, which consists of an automatic gas-air proportioning device, a combustion chamber, a condenser, and graduated control valves.

Head, Wrightson and Co., Ltd., of Thornaby-on-Tees, has received an order from the London and North Eastern Railway Company for 400 additional steel hopper coal wagons of 20 tons capacity each. This follows a similar order received three months ago. It is officially stated that the value of the order is in the neighbourhood of £100,000. Only recently this firm booked an order for 900 wagons for the London and North Eastern Railway.

Aluminium and Its Alloys

By WM. ASHCROFT

Aluminium and aluminium alloys possess a combination of chemical and physical properties which render them suitable for many types of machinery components and equipment. Their light weight and high mechanical performance and their remarkable permanence of properties under physically arduous or chemically corrosive conditions widen the scope for their employment.

As a result of the development of fabricated structures considerable competition exists in supplying the needs of the engineer and much progress has been achieved. Despite progress in the development of more familiar structural materials, aluminium and its alloys are being increasingly applied in various forms, and the rapid progress made is largely due to the results of intensive research work in the development of alloys possessing physical qualities that render them eminently suited to a wide range of applications ; improved technique in manufacture of suitable alloys has made standardisation possible, with the result that there is more confidence in the use of these alloys.

One of the outstanding properties of aluminium is its low density, a factor of importance in reducing operating or transportation costs. In the earlier days the advantage of its weight-saving properties gained some recognition, but a clear conception of the full possibilities of aluminium was not at once apparent. It was not until the end of the nineteenth century that it began to be applied to reduce the dead load in structures concerned with transportation. Its progress coincided with that of the automobile industry, which contributed to aluminium's phenomenal rise in a field which to-day consumes by far the largest percentage of aluminium and its alloys. Early in the present century sheet aluminium had been developed to such an extent that it was used for motor-car bodies, but keen price competition caused it to give way in favour of steel, excepting in omnibuses and many types of commercial vehicles, in which sheet aluminium continues to be used because the weight saving is a vital factor in reducing operating costs.

Use in Transportation Field

In the transportation field the full significance of weight reduction was quickly appreciated on the railways and electric tramways. The high relative cost of power to drive the rolling stock employed was favourable to the use of aluminium alloys, especially as, with the increasing weight of rolling stock and increasing speeds, not only was the cost of motive power greatly increased but the effect on general maintenance was considerable. Investigations soon showed the advantages of employing aluminium alloys and their application to reduce dead weight, consistent with safety and economy, has been demonstrated. To-day the construction of railway coaches for light, fast railways, embodies considerable quantities of aluminium in the form of panelling, seats, window frames, doors and engine gear-cases.

In the more recent developments in the field of transportation-aircraft, this outstanding attribute of aluminium has naturally been of great value to designers and constructors. In this field the use of aluminium and its alloys is almost essential, as the use of a light metal is a first consideration. It is true to say that the development of aluminium and aluminium alloys has prepared the way for the progress experienced in the various types of aircraft. Apart from the reduction of dead weight it seems obvious that equipment demanding repeated movement with the need for rapid acceleration and deceleration should be as light in weight as the economics of engineering materials will permit, and aluminium alloys are proving invaluable in providing the means towards higher efficiency.

The discovery of magnesium, about one-third lighter than aluminium, led to intensive research on aluminium and its alloys with a view to their successful use in fields additional to that of transportation. It was found that they resist more corrosive conditions better than many other metals. The results of researches opened a new field of usefulness in the chemical industry and to-day aluminium and its alloys are being used in the chemical and allied industries to a constantly increasing extent. According to Fink[1] tanks, pipes and fittings, valves, shipping containers, tank cars, tank trucks, centrifugal drying apparatus, stills, condensers, filter presses and numerous other pieces of equipment are now being made in aluminium on account of its fortunate combination of chemical and physical properties.

Corrosion Resistance

Many materials are substantially inert towards aluminium. Distilled water, steam, hydrogen peroxide, concentrated nitric acid, sulphur, hydrogen sulphide, organic sulphur compounds, anhydrous sulphur dioxide, acetic acid, fruit acids, fatty acids, sodium soap, ammonia, turpentine, alcohol, varnish, many dye solutions, beer and milk are among the products which have been handled with advantage in aluminium equipment. The remarkable stability of this metal is due to a very thin, adherent, protective coating of aluminium oxide which forms spontaneously on the surfaces which are exposed to air or even to liquids containing dissolved oxygen or water.

Under certain conditions this oxide film cannot heal spontaneously, such as strictly anhydrous, oxygen-free conditions. Alcohol and some other organic liquids, for instance, which will not react with aluminium if they contain a small portion of water, will pit aluminium readily under strictly anhydrous conditions. Amalgamation also prevents the formation of a protective film and permits rapid oxidation of the aluminium ; erosion or abrasion also, will constantly remove the surface film and expose the underlying reactive metal, but a thicker, more protective and much more abrasion-resistant film can be formed on aluminium by means of a suitable anodic oxidation process.

While aluminium in itself is one of the most stable of commercial metals, even under very reactive conditions, its excellent resistance to corrosion is not, generally speaking, improved by alloying elements. On the other hand, aluminium is relatively weak and, where strength coupled with light weight is necessary, special alloys must be employed or composite materials used. The latter, in principle, have corrosion-resistant surface layers of aluminium or an alloy whose solution potential is such that it will electrolytically protect the underlying core.

Many alloying elements are used to increase the strength and hardness of aluminium, but each has an effect on its corrosion-resisting qualities. The effect of copper and iron, for instance, the latter particularly in the presence of silicon, reduce the corrosion resistance. Zinc and magnesium increase the corrosion resistance of aluminium-manganese alloys, and it is further increased by additions of manganese and tin. The addition of manganese is particularly effective in cases where the aluminium contains appreciable amounts of iron and silicon as impurities. The aluminium-magnesium alloys containing appreciable amounts of magnesium are substantially improved by a solution heat-treatment. This causes the $Al^3 Mg^2$ compound to dissolve, thus giving a homogeneous structure,

1. Symposium on New Metals and Alloys Applicable to the Chemical Industry Division of Industrial and Engineering Chemistry, presented at meeting of American Chemical Society, Pittsburg. Pub. in *Ind. Eng. Chem.* Vol. 28. No. 12. P. 1 402.

which increases the tensile strength, elongation and fatigue strength and, at the same time, prevents the intercrystalline corrosion of these alloys.

Thermal and Electrical Properties

Among the physical properties of aluminium and aluminium alloys which are of a high order are the thermal and electrical conductivity properties. For this reason the metal is used advantageously for heat exchangers, cooling coil fins, and in any equipment where efficient heat-transfer, uniform distribution of heat, and the avoidance of local overheating are important. The high electrical conductivity makes aluminium well suited for the construction of busbars, cables and other electrical conductors required in various electrical operations. The post-war naval programmes, as a result of limitations of tonnages, initiated a campaign not only for lighter machinery, but also for lighter materials of construction for certain parts in shipbuilding; the results obtained from the use of aluminium alloys have led, during recent years, to their introduction into the constructions of naval vessels and passenger ships, and there is every indication that their application will be greatly extended in the near future. Several alloys have been developed which offer considerable resistance to corrosion by salt water, and when the physical properties of these alloys are considered in relation to their specific gravity, it is at once clear that light alloys can be used to effect a substantial saving in weight.

In marine engineering cast aluminium-silicon and certain R.R. alloys, on account of their lightness, strength and corrosion-resisting properties, have been used for a variety of purposes both with turbine and Diesel engine work. Parts such as gear-cases, crankcases, cylinder-head covers, etc., are now used regularly from these alloys.

An interesting application has resulted from the high thermal reflectivity of aluminium. A few layers of aluminium foil separated by air spaces act as an efficient thermal insulation, and in this form it has been applied to milk storage tanks, milk trucks, refrigerators, steam lines, and various other kinds of refrigerated and heated equipment. In the form of aluminium paint this property is proving of great value for protecting petrol tanks, etc.

Many of the alloys now in general application obtain their desirable mechanical properties through heat treatment. In most of the alloys, in which the alloying constituents have a greater solid solubility at elevated temperatures than at room temperatures, heat treatment is possible, hence by heating these alloys to just under the beginning of the melting range it is possible to put the soluble elements in solution. After quenching, some ageing takes place at room temperatures, but this is generally relatively small except in the alloys containing both copper and magnesium. In these latter alloys, natural ageing, caused by precipitation in highly dispersed form, takes place at room temperature and is substantially complete in about four days. The maximum strength and hardness are obtained only by a second heat-treatment, known as artificial ageing or precipitation treatment, which is carried out in the temperature range 120–160° C.

Both cast and wrought alloys may be formed into two main groups: alloys which cannot be heat-treated and those susceptible to heat-treatment. In general, the alloys of the first group are more resistant to corrosion but possess only moderate strength. In both groups there are ranges of alloys which can be cold worked; cold-rolled sheet and plate, for instance, a variety of tempers having different combinations of strength and workability being available Aluminium alloys can be economically extruded into very complicated sections of accurate dimensions. The heat-treatable alloys of highest strength contain copper as a principal alloying element.

In such a short article it is not possible to discuss all the alloys now in general use, but it is remarkable that, although the commercial career of aluminium may be said to have started in 1886, it has achieved fifth place in the family of metals. With increasing competition in various fields, research work is proceeding with greater intensity and in view of the progress already made it can be assumed that the future holds immense possibilities for the further application of aluminium and its alloys.

Electric Drives for Rolling Mills

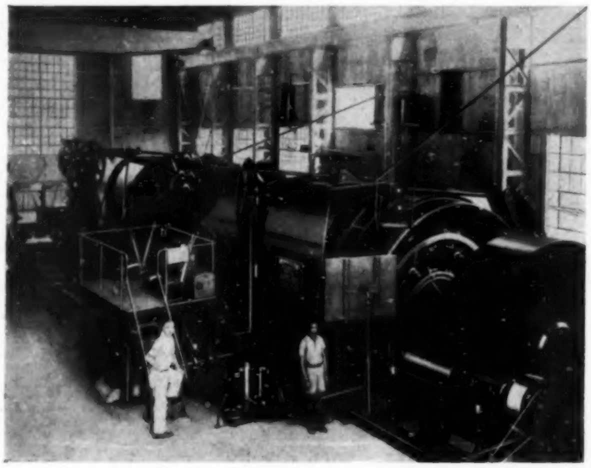
(*continued from page* 68)

d.c. control gear incorporates a number of special features, including special load-limiting control for the edging mill motor, and provision to enable the motor-generator set to be used for supplying power to the general shop supply.

One 3,000-h.p. and one 3,500-h.p. slip-ring induction motors were supplied for driving the Ilgner sets for a plate-mill equipment and cogging mill equipment, respectively, at the Glasgow works of Messrs. Colvilles, Ltd. Each of the motors was supplied with the Metropolitan-Vickers automatic liquid starter and slip regulator.

Individual Live Roller Drives

Now that the steel manufacturers are regarding more favourably the individual drives for live roller tables, much development has been undergone on suitable methods of control. Two motor-alternator sets, with attendant control gear, were recently supplied by Metropolitan-Vickers to Messrs. Colvilles, Ltd., Glasgow; one a constant speed set to supply 38 reversing motors, and the other a variable speed set to supply 49 individual motors.



A general view of two electrically equipped Metrovick winders at Mufulira Copper Mines, Ltd., Northern Rhodesia.

The method of control of each set is very similar, and consists of running the motor-alternator set up to full field speed on the d.c. driving motor, then bringing the individual motors up to speed all together by closing the alternator field circuit and applying over-excitation. This takes care of the heavy starting current peak, and as soon as the motors are up to speed the a.c. volts reach such a value as to operate a pre-set voltage relay, which removes the field forcing and puts the alternator field on normal excitation. From this position provision for reversing is included in the a.c. line on the constant speed set, on account of the infrequent reversals required, whereas on the variable speed set very frequent reversals are required, and are taken care of on the d.c. side.

Interlocking is provided so that the speed cannot be varied from basic until the voltage relay has restored the alternator excitation to normal, and also to ensure that the d.c. driving motor is always restored to the full field condition for starting. Full protection is provided both on the a.c. and the d.c. sides.

It has only been possible to refer to some of the more recent installations for rolling mills, but it will be appreciated that electrical equipment is having a gradually increasing influence in promoting efficient operations in mining and in the ferrous and non-ferrous industries.

Electric Furnaces for Aluminium

By A. J. GIBBS SMITH

The use of the induction furnace for melting metals is not as widespread as other types of electric furnaces, but it offers advantages in dealing with low-melting metals and alloys; details of such a furnace are given in this article.

THE use of aluminium has developed and is still developing enormously, but nowhere is this development more marked than in Germany. As, however, the industry there is so largely dependent upon foreign sources of supply, it is considered important from the point of view of national economy that this relatively expensive metal should be melted under such conditions as to involve the least possible loss through oxidation, and there is also a very general demand that castings should be free from all impurities, such as Al_2O_3. The questions of melting loss and the quality of the product are recognised to be mainly dependent upon the type of furnace and the method of heating employed, and it is for these reasons that electricity has been found to offer considerable advantages for melting aluminium. Electric furnaces are now employed for this purpose, varying from the smallest crucible type up to those with a capacity of 1 ton per hour.

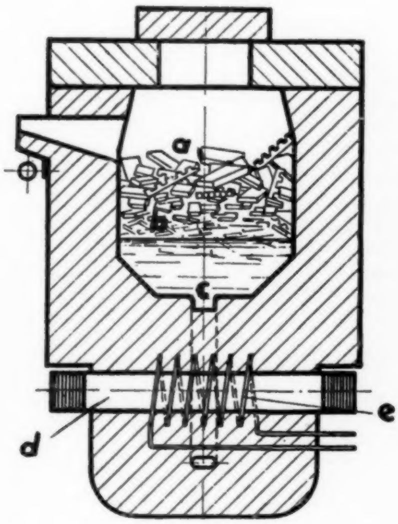


Fig. 1.—Section through induction furnace.

Fig. 3.—10 cwt. induction furnace at work melting aluminium and light-metal alloys.

The induction furnace is a type whose use is not so widespread as either the arc or resistance types, the proportions of the different classes in use being approximately in the order of arc 7, resistance 3, and induction 1; nevertheless, the latter has many interesting points in its favour, and its own particular field of utility. For melting aluminium and metals or alloys with a fairly low melting point, the "Russ" furnace has been developed on this principle, which is giving some interesting results, and which has been the means of reducing current consumption per ton of aluminium down to about 360 k.w.h. A feature of this furnace is that there are no wearing parts apart from the refractory base and pouring lip, the regular replacement or renewal of heating elements, crucibles, electrodes, etc., being done away with.

The principle of the furnace is shown by Fig. 1, from which it will be seen that the melting chamber A receives the charge B, the small molten charge forming the sump being shown at C. D is the transformer, with its primary winding E. Fig. 2 shows a complete installation of this type arranged below the floor level of the foundry. The capacity of the furnace shown is 10 cwt., and it has an output of 7 cwt. of aluminium per hour. It will be noticed that it is of the tilting type, the body being swung from a point level with the lip, so as to give a constant pouring point, which is of importance when pouring direct into cast-iron moulds. At the rear of the furnace an electrically operated winding gear provides for a regular and easy pour of the charge either into moulds or ladles.

The photograph reproduced at Fig. 3 shows another similar installation at work, the pouring point of the furnace in this case being arranged 20 in. above the foundry floor for pouring into hand ladles. The switchboard permitting the rate of working to be controlled exactly is shown at the rear.

As a consequence of recent improvements, it has now been found possible to provide a furnace lining which will give a minimum life of 3,000 heats. Moreover, an entirely new lining can be fitted to the furnace in a couple of shifts, the cost of this being no more than the price of a few crucibles of this large capacity. Metal loss when melting aluminium has been reduced to 0·8%, as against 1·5% in an oil-fired furnace.

Some useful figures of comparison are now available of melting results in an induction furnace of this type, as against those obtained with an oil-fired furnace, all the data having been obtained from actual practice. The comparison is based upon a daily melt of 5 tons of aluminium, a five-day working week, and 250 working days per year, the figures being calculated to cover an entire year's working. The basic data for the comparison in metric figures, with the equivalents in English measurements, and price conversions at par, are as follows :—

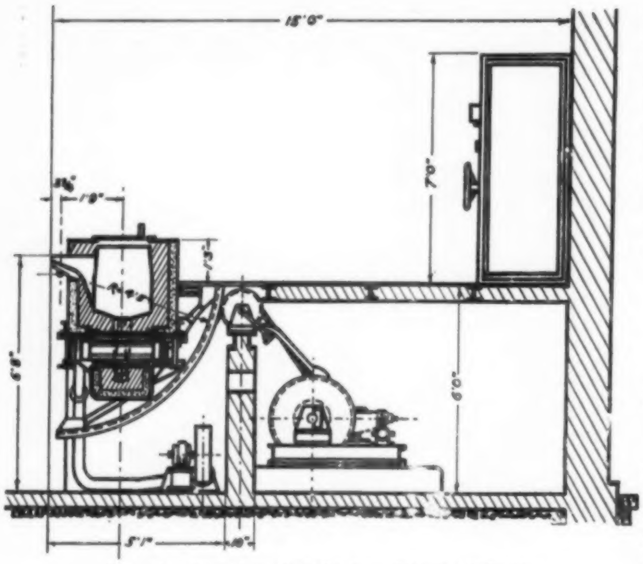


Fig. 2.—Complete installation, 10 cwt. induction furnace for melting aluminium.

Oil (0·11 R.M. per kilog.)	£5 9s. 4d. per ton
Electricity	0·4d. per kw.h.
Oil-fired furnace consumption (140 kilog. per ton)	1½ gal. per cwt.
Induction furnace	360 kw.h. per ton
Melting loss in oil-fired furnace	1·5%
Melting loss in induction furnace	0·8%

Price of aluminium 1·30 R.M. per kilog. = £64 13s. per ton. On the foregoing basis, the two types of furnace compare as follows :—

OIL-FIRED FURNACE.

	£
Melting loss (5 t. × 250 days × 0·015 × 1·30 R.M. × 1,000 = 24,400 R.M.)	1,191
Cost of oil fuel (5 t. × 250 days × 140 kilog. × 0·11 R.M. = 19,250 R.M.)	944
Repairs (2,500 R.M.)	123
Interest (4,000 R.M. at 7% = 280 R.M.)	14
Depreciation (4,000 R.M. at 15% = 600 R.M.)	30
	£2,302

INDUCTION FURNACE.

	£
Melting loss (5 t. × 250 days × 0·008 × 1·30 R.M. × 1,000 = 13,000 R.M.	632
Energy (5 t. × 250 days × 360 kwh. × 0·033 R.M. = 14,850 R.M.	728
Repairs (one new lining, 1,000 R.M.)	50
Interest (25,000 R.M. at 7% = 1,750 R.M.)	86
Depreciation (25,000 R.M. at 15% = 3,750 R.M.	184
	£1,680

Fig. 4.—Section through metal melted in induction furnace.

Fig. 5.—Section through metal melted in oil-fired furnace.

It will be seen, therefore, that the total melting costs per ton for the induction furnace are £1 6s. 10d., against £1 16s. 10d. for the oil-fired furnace. Apart from this, however, a very considerable improvement in the quality of the castings is claimed, as castings poured from the induction furnace are practically gas-free. For the purpose of illustrating this point, Fig. 4 is a section through the gate of a casting, the metal for which was melted in an induction furnace, while Fig. 5 shows a similar section, the metal in the latter case being brought down in an oil-fired furnace. It will be recognised, therefore, that apart altogether from the question of melting costs, recent continental experience indicates that the induction furnace is a type which is well worthy of careful study, particularly on account of the quality of the metal obtained by this special method.

Relief Scheme for Jarrow

(Seamless Tube Works)

THE scheme for the installation of a seamless steel tube works at Jarrow, in which Sir John Jarvis, M.P., is the moving spirit and which is sponsored by Messrs. Stewart and Lloyd, Ltd., and Tubes, Ltd., has now taken practical form, and the piercing and rolling unit has been ordered from Maschinenfabrik Meer A.G., Gladbach, Germany, as the result of experts' visit to Birmingham in October, 1936. The sizes to be manufactured are from 3 in. down to the smaller diameters, for which there is an increasing demand.

As a fillip to British trade it was suggested that part of the plant should be made in England, viz., bed-plates, standards and the like, but after consideration of the scheme a decision was reached to obtain the mills as a complete working unit from the German manufacturers, which, in the opinion of experts, is a wise move.

The new factory, which is being erected on the old site of Palmers Shipbuilding Co., Jarrow-on-Lyne, adjacent to the works of the late Tyneside Brass and Copper Tube Works, is expected to be in full operation in June of this year. Mr. Ben Price, late of the Mannesmann Tube Co., Ltd., Landore, South Wales, has been appointed as practical consultant, and negotiations for the plant have been conducted through Mr. J. O. Hara Murray, M.I.M.E., 66, Hatton Gardens, London, E.C. 1, the sole representative of Maschinenfabrik Meer A.G. in Great Britain. It is of interest to note that this firm recently supplied to a leading concern a Pilger mill capable of dealing with tubes up to 21 in. external diameter. This latter plant is claimed to be the largest in use in the world's steel tube trade, and in its construction many new ideas have been incorporated, particulars of which we hope to publish shortly.

The firm of Meer A.G. is now associated with the Mannesmann Brothers, who, in 1888, introduced their well-known piercing and rolling process to Great Britain, and it is anticipated that during 1937 their latest process of tube manufacture will be introduced to this country, which may have as far-reaching an effect on the ferrous and non-ferrous trade as did the original rotary and piercing Pilger mill in 1888.

Spray Treatment for Firebrick Work

A FIRE cement gun has been developed for coating, washing, and spraying large firebrick surfaces, such as in boilers, kilns, coke-ovens, cupolas, retorts, etc., which is claimed to be the speediest method of covering such surfaces. Not only is time and labour saved, but a coating or sprayed application is more permanent. The impingement of the cement penetrates the pores of the brickwork and fills up all cracks, interstices, and corners.

The gun, which is supplied by J. H. Sankey and Son, Ltd., The Hill, Ilford, Essex, operates under an air pressure of 40–50 lb. per sq. in., and is designed and constructed to give lasting service. When used on old and well-worn firebrick work, considerable thicknesses of cement beyond ⅛ in. to ¼ in. can be built up, and there is no waste of cement on application.

Some Factors which Influence the Production of Seamless Tubes

By GILBERT EVANS

Many difficulties have been overcome in the manufacture of seamless tubes, but many factors are involved which continue to cause trouble and make tube manufacture very complex. Soundness of material is of primary importance, and the subsequent inspection of the finished tubes leads to greater confidence in their use. In this article these factors are discussed and reference made to equipment and processes to facilitate the production of sound tubes.

THE quality of a finished tube is dependent upon the care taken in the initial manufacture of the material of which it is composed, and the conditions under which the material is prepared for the tube mill. Various preparatory processes are involved before the material reaches the tube mill in a suitable form, and experts in these processes have become necessary; while it is not intended to cover these various sections, a number of aspects can be profitably discussed.

The Necessity of Soundness of Material

Although vast strides have been made in the smelting, rolling, and manipulation of steel for use in production of seamless tubes in recent times, the liability of having to deal with faulty material remains, as it has been since the introduction of the rotary or cross-roll process by the Mannesmann brothers in 1885—the ever-present bugbear of tube-makers. Even when submitted to a pickling in weak acid solution for removal of surface scale, the round billets develop minute cracks and longitudinal seams, while in similar manner blow or air-holes appear in the cross sections of the cut billet. Probably more law cases have been contested over material supplied as suitable for rotary process and found unable to withstand the torsional strains than in any other branch of the industry.

The liability of defective billets is an ever-present menace, but certainly not to such an extent to-day as in earlier days. Efforts to remove roaks and spills by hand hammer and chisel were wasted time and labour, and were ultimately succeeded by the introduction of the pneumatic hammer. But recently an oxy-acetylene flame surface process has been evolved which promises to effectually remove the menace to production of the perfect tube in certain classes of material, though its application to high carbon and alloy steels has been recognised as very limited. Undoubtedly success has been achieved in dealing with steel containing up to 0·30 carbon.

In addition to its effectiveness, the flame process has other details in its favour, chief of which are its cheapness in application, ability to deal effectively with large tonnage, and extreme handiness for conveyance to different treatment sites. This handiness will be obvious in comparing the 12 lb. weight of the outfit with the probable 25 lb. weight of the standard pneumatic hammer and armoured hosing. To a great extent the success of the treatment depends on the stage of manufacture at which it is introduced. In the process of converting the cast ingot into round or circular form, the material is hammered and/or cogged in the rolling mill in the initial stages, and while under the former treatment certain visible defects are removed.

It is when the slab or square section in rolling has been reached that the oxy-acetylene treatment is applied. The surface of the material is then in a comparatively clean state. At this stage the rolled square section is immersed in pickle for a period of approximately two hours for the removal of mill scale. It is subsequently inspected and the defective areas are marked. These defects are classed as roaks, seams, air blisters and fins.

The flame treatment, which should be applied intelligently, is carried out as follows: In the event of the beginning of any of the defects being near the end of the slab, the edge of same is ribbed or slightly burred up in line with the defect by a blow from a hand hammer. The object of the burr is to provide the operator with a start for the apparatus, and obviates the possibility of him gouging a deep hole in the surface of the slab. Should the defect be away from the end, a rib or burr is cut and turned up to ensure the necessary start.

In application, the oxy-acetylene flame is directed at a narrow angle to the surface of the material under treatment, with the result that a shallow groove is cut free from the sharp corners and waviness such as are caused by ordinary hand or pneumatic hammers. The importance of the shape of the channel needs no emphasising, removing as it does the liability of chisel-cut corners rolling in during subsequent rolling operations. As the flame is directed almost parallel to the slab's surface, the apparatus will produce a channel curved in shape about $1\frac{1}{4}$ in. wide and $\frac{1}{16}$ in. to $\frac{1}{8}$ in. deep. As a time saver its value is enormous.

Careful records were made as to loss of material by the pneumatic hammer in comparison with that under the flame operation, and results were as follows: Loss by first-named treatment, 21 lb. per ton, and by the latter 30 lb. per ton. This loss of material was more than compensated for by the difference in costs—viz., 10s. 6d. per ton for hammer as against 4s. for flame treatment. At the moment, the writer cannot visualise the new process being successfully applied to finished circular billets ready for piercing in a rotary Mannesmann or Stiefel type mill.

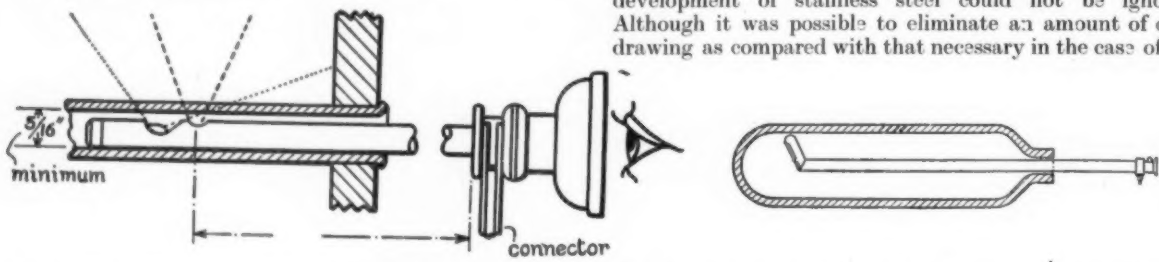
For the benefit of those unacquainted with the intricacies and working of the rotary piercing machine, and the need of steel as near perfect as possible, it must be explained that in both the processes mentioned the steel billet, at a temperature of 1,400–1,450° C., is subjected to extreme torsional stresses set up between rolls and/or discs with varying circumferential speeds, while being forced over a mandrel or piercing head.

At an early stage in the development of the Mannesmann type of mill, claim was made that the process produced "the only tube with a spiral fibre," a claim which was quickly abandoned when the effect of the piercing operation on the material was scientifically investigated. Needless to state that the evolution or development in this type of mill since those pioneer days has greatly improved, in conjunction with better material, the value of such manufacturing plant.

Reverting to the oxy-acetylene flame process. It is understood that a long period—estimates of such time vary considerably, but probably 18 months to 2 years—was spent in the experiments which led to ultimate success and adoption by the largest manufacturers of seamless steel tubes in America. From details available it is realised that the burner under review has been evolved from the standardised type in use for cutting purposes. The pressures from the main supplies are about 90 lb. per sq. in. for oxygen and 15 lb. per sq. in. for acetylene. The apparatus is made under exclusive patent rights, and

includes devices to prevent back-fire from premature combustion, special ignition, etc., while the whole of the trigger gadgets are completely under simple control of the operator.

As a practical expert in the manufacture of seamless steel tube, the author welcomes the introduction of this new process, and fully realises its possibilities. The writer has no claim to intimate practical knowledge of the processes of cogging and rolling between the casting of the ingot and its final transference to the tube mill in round billet form, so realises that some slight changes may be necessary in order to take full advantage of the invention. From the practical tube-maker's point of view, the nearer the approach to steel billets free from surface defects, the more his worries and anxieties are reduced. This especially applies to users of the skew rolls (Mannesmann) and disc (Stiefel) piercing plant. Other concerns in which the Ehrhardt, Robertson, and others vertical or horizontal straight-push processes are used will also welcome such a simple solution of at least some of their troubles. At the time of writing this process has not been successfully applied to alloy or high-carbon steel, but experiments on these qualities are being conducted.



A low-power microscope designed for the internal inspection of long lengths of steam, condenser and other tubes; two applications are shown and some indication given of the field covered.

Intensive Tests and Inspection

In spite of the increasing all-round excellency of the finished tube, due to the amalgamation of practice and technical research, there is no slackening on the part of consumers, as is reflected in specifications governing tolerance in limits of diameter and gauge or wall thickness, weight, appearance, and finally quality. The increasing severity of specifications in general appear to keep step with improvements in method of manufacture. Especially is this noticeable in the non-ferrous branch.

Prior to the adoption of extrusion, condenser tubes of 20/30 alloy Admiralty mixture were made from castings in close grey cast-iron split moulds in which a sand core was used. In most modern plants this class of split mould has been almost entirely replaced by water-cooled moulds, some of which have copper liners for the reception of molten metal. This method has proved its value in improved surface and quality; the comparative high metal cost, however, makes it, in some cases, prohibitive to the smaller tube makers.

The castings, after pickling, had to be bored out on the inside and reduced on the outside, so that a high percentage of scrap occurred in the first treatment. Inspection of surfaces was then made by an Admiralty inspector, who stamped each individual machined casting, which was invariably obliterated in the first drawing on the bench. In all factories special boring and turning plant had to be provided, and, in fact, the cost of manufacture was so increased that many firms preferred not to have such orders on their books.

In the operations following the first draw pass, the iron frames of transport bogies had to be lined with canvas and sometimes flannel as a protection against scratching or similar defects. Special lubrication was necessary for the final finishing draws, and so on up to the inspection department. The treatment in this stage was reduced to a fine art, physical and analytical tests were watertight in their completeness. The tube was heated by the application of steam to the inside, and further expense was added to the cost of manufacture by the inception of an optical inspection of the bore for which purpose a costly mirror arrangement with reflected lights was necessary. Finally, compressed-air connections and jets or nozzles were installed, and very delicate silk or woollen wads were blown through the tube from each end, and any adherence of a hair of this fine material to the inside of the tube was taken to be indicative of a flaw, providing a spot for the setting of an attack by corrosion.,

It is hardly necessary to state that under such conditions and difficulties, output was much reduced, and firms who undertook orders were able to demand almost their own price. With the introduction of the extruding process, conditions of manufacture were somewhat improved, but only after a long experimental period. It was demonstrated that different alloys required different heat-treatments, and different rates of extrusion, while the working conditions in casting the solid billets also advanced. High-grade steels had to be formed for extruding dies and mandrels, the bogey of eccentric wall thickness was a continual menace and threatening competition from the development of stainless steel could not be ignored. Although it was possible to eliminate an amount of cold-drawing as compared with that necessary in the case of the casting on sand-core method; it had to be decided what minimum number of drawing operations produced the most perfect condenser tube.

All these obstacles and others not referred to had to be, and were, overcome, yet what maker would definitely state that the perfect tube has yet been produced? While these remarks have been confined to conditions governing the manufacture of condenser tubes, similar conditions prevailed where locomotive, steam tubes, and the like were concerned, so that it is safe to say that in the difficult art of tube-making progress has not marked time.

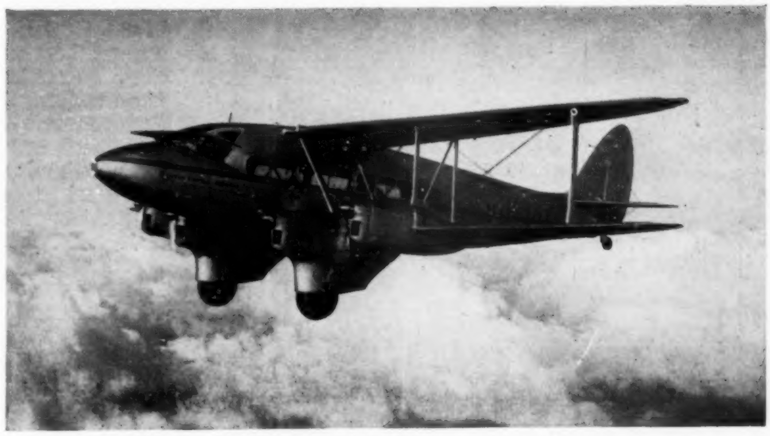
Examining for Internal Defects

One of the latest scientific additions to the inspection department is an instrument by which a definite attempt has been made to decide whether internal defects are existent. This instrument is virtually a low-power microscope, carrying its own illumination, supplemented by an optical system which transmits the image to the user's eye. A prism and small electric lamp are inserted in the bore of the tube, and in conjunction with a series of mirrors and a special design of eye-piece, an intensive inspection of any doubtful area is brought under the critical eye of the inspector.

In long lengths of steam, condenser and other tubes, it would be necessary to examine from either end, as the fact that a defective area may exist some distance from the eye-piece does not interfere with the efficiency of the, instrument. Two of its various applications are clearly demonstrated in the accompanying illustrations. Its aid in the examination of gun barrels, tubes, gas bottles or other articles with deep interior surfaces is very great. The angle of light is shown by dotted lines, while the angle of vision is represented by dashes. Incidentally, the introscope has proved of inestimable value in the examination of tanks, spar structures, and oil coolers of all classes of lighter-than-air machines.

MAGNESIUM ALLOYS

An account of developments during the last three years in the production of magnesium alloys suitable for aircraft construction is given in a paper by Dr. C. H. Desch, F.R.S., before the Royal Aeronautical Society, on January 14. The author discusses the heat-treatment of castings and the hardening by ageing of forged alloys, as well as the conditions affecting forging at various temperatures. An abridgement of the paper is given in this article.



A de Havilland Air Liner in which Elecktron magnesium sheet by James Booth & Co. Ltd., is used.

THE production of magnesium has increased in recent years, although figures are difficult to obtain. The most convenient source is still the mineral carnallite, a double chloride of magnesium and potassium, from which the metal is obtained by a fairly simple process of electrolysis, but as this mineral is of quite local occurrence, apart from the extensive deposits of Strassfurt and elsewhere in Germany, other countries have made efforts to use more available sources. These include sea water, which contains chloride ; the native carbonate, magnesite ; and dolomite, the double carbonate of magnesium and calcium, which demands a preliminary separation of the compounds of the two metals from one another. Several processes are therefore in use, and these are no longer confined to electrolysis, as a purely thermal reduction at a high temperature, although involving great difficulties in the construction of plant, has been successfully used to a limited extent on a manufacturing scale (4, 5.)

Magnesium is too weak a metal to be used in the unalloyed state, and the metals which may be added to it to produce strong alloys are very limited in number. This may be deduced on theoretical grounds. Hume-Rothery has shown that solid solutions, which are necessary for any considerable strengthening, cannot be formed to any appreciable extent if the atomic diameter of the added metal differs from that of the solvent metal by more than about 14% (6). When this rule is applied to magnesium, it is found that the following metals fall within the limits :—Lithium, aluminium, zirconium, silver, cadmium, tin, antimony, gold, mercury, thallium, lead and bismuth. Several of these, however, including tin, antimony, thallium, lead and bismuth, form compounds with magnesium which are both brittle and reactive, so that they can only be added sparingly, if at all, and when all the factors are taken into account, we are left with only aluminium and cadmium as suitable for alloying in more than quite small quantities. On the other hand, calcium, cerium, zinc, nickel, cobalt and manganese, which fall outside the limit and can only form solid solutions to a very limited extent, have proved useful in small quantities.

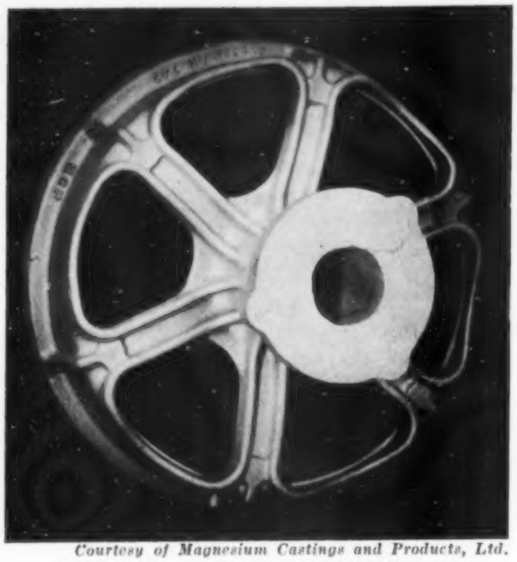
To those who have only known magnesium in the form of ribbon or powder for use in flashlights, and have noticed its ready inflammability, it is rather surprising to find that magnesium alloys are remarkably easy to cast. This comes partly from the fact that molten magnesium has very little power of dissolving gases, so that ingots and castings do not suffer from the sponginess caused by the liberation of dissolved gases at the moment of freezing. The shrinkage of magnesium alloys in the mould is nearly the same as that of the common casting alloys of aluminium. It is necessary to use a suitable flux, consisting of mixtures of chlorides and fluorides, to protect the surface against oxidation, and to use a protective atmosphere during pouring, but these conditions are now well understood, and no difficulties are experienced in the foundry.

The protective atmosphere is obtained by mixing certain substances, notably sulphur, boric acid, ammonium bifluoride, or mixtures of these, with the sand used in moulding, and sprinkling the same compounds on the surface of the metal during pouring. During annealing processes, a similar protection may be obtained in one of two ways, both of which are in industrial use. Either a muffle may be used, in which an atmosphere rich in sulphur dioxide is obtained, as for instance by strewing the floor with iron pyrites, or the objects may be heated in a salt bath, a suitable composition being 72% sodium dichromate, 24% potassium dichromate, and 3% potassium chromate, the last-mentioned salt being added to prevent the gradual reduction by magnesium which would otherwise form a sludge. Mixtures of alkali nitrates and fluorides are also used. Simple nitrate baths, as used for aluminium, are out of the question on account of chemical attack.

These precautions show that a special technique has to be adopted in the making of castings or forgings of magnesium alloys, but that no special difficulties are involved, and a magnesium alloy foundry is in fact a remarkably clean and inoffensive place. Comparatively large gates and risers are necessary, but as the scrap may be remelted with very little loss or deterioration this is not of serious consequence.

Casting Alloys

Full advantage may be taken of the excellent casting qualities of magnesium for the construction of aircraft parts which are not to be too highly stressed, it being possible to make intricate shapes without great difficulty. The strength may be increased, and the ductility improved, by an annealing treatment which brings a larger quantity of the alloying elements into solid solution, producing a homogeneous structure. A subsequent treatment at a lower temperature, whilst lessening the ductility, increases the hardness by precipitating a constituent in a fine state,



Courtesy of Magnesium Castings and Products, Ltd.
Hub and rim portion of an aircraft landing wheel.

Both sand and chill castings are used. By casting in dies, very satisfactory castings, needing a minimum of machining, are obtained, with a higher strength than sand castings.

One of the most valuable means of increasing the strength of an alloy is by the process known as age-hardening. The process depends on finding some constituent which may be added to an alloy, capable of passing into solid solution at a high temperature and being retained on quenching, but separating, at first in an ultra-microscopic form when the quenched alloy is heated to a lower temperature, or, in some instances, even spontaneously at the temperature of the air. Generally speaking, to obtain any considerable increase of strength, the added constituent must have a high solubility just below the melting point, falling rapidly with falling temperature. Magnesium does not, as a rule, form extended solid solutions with other elements, but investigations show that the following metals, in descending order, have a fairly high solubility when hot, in all cases diminishing rapidly on cooling:—thallium, lead, tin, bismuth, silver, aluminium, zinc manganese, calcium. Some of these alloys have been only imperfectly investigated, but the order is approximately correct. Several of the metals mentioned, such as lead, can be at once ruled out, both on account of weight and because they form compounds with magnesium which are decomposed by water. One of the chief difficulties with which the metallurgist has to contend in devising new alloys of magnesium is its strong tendency to form compounds, often of a reactive kind, with other metals.

Cast alloys of magnesium with most metals give poor mechanical properties, and only those containing an appreciable quantity of aluminium are strong. Most of the castings of magnesium alloys made in metal moulds are cast by gravity, but true pressure die-casting is also employed with success, certain precautions having to be taken on account of the reactive nature of the metal, which absorbs not only oxygen but nitrogen with avidity. Unlike aluminium, the molten alloys do not attack the iron or steel dies. The surface of the metal is protected by an atmosphere of sulphur dioxide and sulphur vapour.

Castings of magnesium, like those of other metals, may be examined for soundness by means of X-rays, and the low density allows of great penetration. The exposure for a magnesium casting 6 in. thick is the same as for one 4 in. thick in aluminium, but the contrast is weaker. It is therefore advisable to use a lower voltage on the X-ray tube than usual. A method has been devised by Messrs. High Duty Alloys for impregnating the castings under pressure with a substance highly opaque to X-rays, thus making the defects clearly visible.

Working Properties

The mechanical properties of magnesium, which are shared by its light alloys, and determine their behaviour in rolling and forging as well as their strength and ductility in use, depend on the crystal structure to zinc, cadmium and solid mercury, but having certain peculiarities of its own. In a cubic metal, such as copper or aluminium, there is a number of similar planes on which slip can occur, so that extensive deformation is possible by alternate slipping on several, but in a hexagonal metal slip only occurs, at least at the lower temperatures, on a single set of planes, the basal planes of the hexagonal prism. Slip in each crystal therefore takes place only in one direction, and deformation is restricted. The process is often complicated by twinning.

This peculiarity is shared by zinc and cadmium, but the three metals differ considerably in their behaviour on deformation. This is because the hexagonal structures are not quite the same. The unit of structure of each is a hexagonal prism, but that of zinc may be regarded as being slightly elongated, as compared with the most closely packed arrangement possible, whilst that of magnesium is slightly compressed. Although the mechanics of the process are not completely worked out, it is certain that the effect is to make magnesium still less isotropic than the other related metals.

It is the presence of these planes of easy slip that makes the deformation of magnesium so anomalous. In the process of working, the crystals of which the mass of metal is made up, tend to rearrange themselves so that their basal planes are as nearly parallel as possible, making deformation in any but one direction very difficult. Thus the yield point in tension differs from that in compression in a forging made under normal conditions. It is even possible to have ductility in one direction and brittleness in another. This difficulty is overcome by making the crystal grains as small as possible. The condition of the ingot largely determines the behaviour of the metal in forging, and small grain size in the ingot is obtained by casting from a high temperature.

In the subsequent working the object is to check this "preferred orientation," and this may be controlled by taking advantage of three factors. In the first place, when the temperature of deformation is above 225° C., although most of the slip occurs on the basal plane as before, certain other planes (the "first pyramid" planes), come into play, so that each crystal has six new possibilities of slip. Thus when all the malleability due to the basal plane is exhausted, other planes become available.

The second device is that of changing the direction of working. If the metal can be squeezed, first in one direction and then in another, a much greater degree of deformation is possible than in a simple operation, such as rolling. Lastly the time factor has a very great influence. Magnesium and its alloys may be deformed slowly, when quick working at the same temperature and with the same stresses would cause cracking.

The practical working of the alloys takes advantage of all these factors. The ordinary way of breaking down the structure of the ingot, by rolling or hammering, readily causes cracking of magnesium alloys, even when the reduction at each stage is small, and this is one of the principal difficulties of manufacture. On the other hand, when the surfaces of the mass of metal are confined, much greater deformation is possible. Two methods fulfil this condition; extrusion and pressing between heated dies, and both are applied successfully in practice. All the light alloys of magnesium may be extruded, the speed being kept low, and this is the usual method of production of much of the material as used in industry. Besides this, pressing in such a way as to constrain the flow of the metal is very widely applicable. When a series of operations is necessary, each successive pressing should be at a lower

temperature than the last. Drop-stamping and forging are, however, quite practicable, provided that means are taken to ensure a fine grain structure in the initial material. Naturally, care must be taken to work within a suitable range of temperature, and to adjust the amount of deformation at each successive stage by trial.

Rolling gives a structure with highly directional properties. Rolling at a very slow speed allows of much more change of section without cracking than does the practice usual with other metals, and mills run at a very low speed are used industrially. The production of sheet naturally presents special difficulties. In rolling, the basal planes of the crystals tend to set themselves parallel with the surfaces of the sheet, giving a high yield point but low ductility. If, therefore, the sheet has to be bent at all severely in the course of construction, the operation must be carried out hot. In order to break up the structure as far as possible, the last pass should be a reduction of 10% by cold-rolling, followed by annealing. Where intermediate annealings are necessary, there is always the danger of excessive grain growth. A certain critical deformation is usually necessary to cause the growth of very large grains when a metal is subsequently annealed, but with magnesium this tendency is strongly marked, and the critical deformation extends over a comparatively wide range.

Courtesy of High Duty Alloys, Ltd.

Group of small stampings and pressings, showing three operations in the production of a larger forging.

Wrought Alloys

It is naturally in the field of wrought alloys that there is the largest scope for the production of new alloys with improved mechanical properties. Magnesium has one disadvantage which cannot be removed by alloying, namely, a low elastic modulus of $6 \cdot 2 \times 10^6$ lb./in.^{2}, against 10×10^6 for aluminium, and this fact must be allowed for in design. On the other hand, the high elastic hysteresis gives it great damping capacity, so that vibrations, as in an airscrew, are prevented from reaching a dangerous amplitude. The alloys are sensitive to concentrations of stress, especially under alternating stresses, so that it is important to avoid sudden changes of section.

The simple binary alloys with metals other than aluminium do not, so far, offer great advantages. Cadmium alloys readily with magnesium, the tensile strength being little changed, even by large additions, but the alloys are very ductile, the elongation increasing with increasing cadmium up to 20% on 2 in. with 15% Cd., and this property is retained in the ternary alloys with cadmium and zinc. Rolled strip containing cadmium 4, zinc 4%, gave a tensile strength of 17·2 tons/in.^{2} and an elongation of 22%. This strip could be spun cold into simple forms if given several intermediate annealings. Higher strengths, with somewhat less ductility, were obtained from alloys containing cadmium together with aluminium.

For highly stressed parts it is necessary to raise the proof stress as well as the tensile strength, and for this purpose some form of age-hardening would seem to be desirable. Of the metals which might be added to the standard alloys with this object, silver seemed the most promising, and its effect on several alloys has been examined. An alloy with aluminium 8%, cadmium 8%, and silver 2%, in the form of 1 in. forged bars, after a treatment consisting of heating two hours at 410° C., quenching, and ageing for six days at 130° C., gave a tensile strength of 27·6 tons/in.^{2} 0·1% proof stress [3] 19·5 tons/in.^{2}, and elongation 4·2%. Other alloys, after similar treatment, gave the following results :—

Aluminium.	Silver.	Composition Zinc.	Manganese.	Calcium.	Tensile Strength, Tons/in.^{2}	Proof Stress, Tons/in.^{2}	Elongation %.
0	2·5	—	0·4	0·2	25·2	17·0	3·5
5	2·7	0·7	0·4	0·3	25·8	17·3	6·0
5	3·0	—	0·3	0·2	25·1	16·4	4·0

It has been found possible to obtain similar properties, including the high-proof stress, from large forgings made in the press. It seems, therefore, that age-hardening may be applied with decided advantage to alloys of this class.

The following figures have been obtained from propeller blades forged in the press, the alloy being slightly modified from the usual composition, without age-hardening, but with careful control of the crystal structure during the forging operations :—

Tensile strength	20—23 tons/in.^{2}
0·1% proof stress	12—14 „
Elongation	5—11%
Wohler fatigue range	*7·5—8·5 tons/in.^{2}

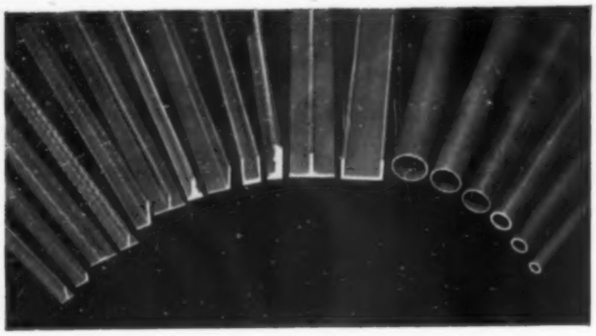
* Patent application No. 12659, 5/5/36.

Magnesium Alloys at High Temperatures

The strength of magnesium alloys falls off rapidly with increasing temperature, but the rate of fall varies greatly with the composition, so that a choice of alloys has to be made. It is evident that heat treatments to give improved strength, other than a simple solution treatment to render the alloy homogeneous, are out of the question, as the working temperature will be high enough to undo their effect. The problem of finding suitable alloys then resolves itself into that of discovering structures of inherent strength at high temperatures, stable under prolonged heating or repeated intermittent heating and cooling. This does not necessarily mean using homogeneous solid solutions, as a network structure may be present, provided that it is not one which is absorbed and reprecipitated within the working range of temperature.

The required properties cannot be determined by simple tensile tests at high temperatures, using rates of loading similar to those of the ordinary tests. Creep becomes important, when the stress is continued for a long time. Few of the alloys have been tested under rigorous creep conditions, and the data available have been mostly obtained from accelerated tests. For the alloys containing aluminium. however, some general conclusions have been given. As with other metals, cast alloys have better creep resistance than forged, but by suitable heat-treatment the structure may be made to approach more nearly to that of the cast alloy, whilst the precipitation of a constituent from solid solution during heating under load has a weakening effect.

In the course of tests at the N.P.L., aluminium, silver, manganese, calcium, nickel and cerium were found to strengthen magnesium, the strength-temperature curves being raised throughout their course, whilst combinations of two metals have a rather greater effect than one alone. Calcium is a useful addition for this purpose, with the added advantage that it is actually lighter than magnesium and that it improves the casting properties. So small a quantity as 0·35% has an effect. Cerium in the order of 1%, has a marked strengthening effect at 300° C., whilst when nickel is also added the hardness is similar to that of Y-alloy in the same range of temperature. Nickel, however, has the disadvantage of making the alloys very



Courtesy of Reynolds Tube Co., Ltd.
Typical examples of tube and sections.

corrodible, and cobalt has given better results.* The following tests were obtained from forged material :—

Alloy.	Temperature, °C.	Tensile Strength, Tons/in.²	Elongation, %
Cerium, 10%	20	18·6	0
Cobalt, 1·5%	100	15·2	2·4
	200	13·2	2·0
Manganese, 1·5%	300	7·4	1·2

Cadmium, lithium, thallium, lead, zinc, tin, copper and silicon were found ineffective as means of improving the properties at high temperatures.

Data as to the actual properties of the alloys under prolonged stress when hot are still rather scanty, and makers have been forced to use the rough guide provided by short time tests at high temperatures. It is particularly in the neighbourhood of 140° C. that information as to the behaviour in creep is required, on account of the application to crank cases, etc. The suitability of the alloys for pistons is determined by a combination of qualities, of which resistance to creep is not the most important. Permanence of dimensions, resistance to fatigue, stability of internal structure (absence of changes leading to increased brittleness), thermal conductivity, are all properties of significance in this connect on, and a more thorough study of these properties is essential. Pistons made of alloys similar to those mentioned have, however, given excellent results in trial runs under overload, and it is probable that improvements in composition are the best means of obtaining better performance.

An obvious difficulty in the use of alloys of magnesium is their ready corrodibility. Magnesium is a highly reactive metal, which can even decompose water. No addition of an alloying metal, in quantities within the range of the light alloys, will inhibit this corrosion, although the influence of small quantities of manganese is known to be favourable. A simple film, formed by exposure to air affords some protection, so that a specimen left in the open in a fairly clean atmosphere will only show a thin white crust. Lanoline affords some protection, but it is usual to employ a chemical treatment with the object of forming an adherent protective layer, united chemically and not merely mechanically to the metal. Three such treatments have been devised, using chromate, fluoride and selenium respectively. The production of a chemical film is intended not only to protect by itself against atmospheric attack, but to serve as a basis to retain a coating of varnish, paint or enamel.

The protection of the surface of airscrews presents a specially difficult problem. Here it is not so much a question of chemical corrosion, as rather of abrasion of the leading edge by dust particles and rain drops, in consequence of the high velocity. When the air contains salt particles also, this action is greatly accelerated. Marked differences are found between different climates in this respect which are not completely accounted for by the prevailing winds, and the nearness to the sea. Even the very adherent coating produced by the chromate treatment suffers under abrasive conditions, and paints and enamels prove inadequate. Treatment with chromate, followed by lanoline or a varnish with a base of tung oil, affords as much protection as can be expected, but there is room for improvement in this direction. Where the air is charged with fine particles of sand, as in Iraq, the abrasion is such as to put metal airscrews out of the question, at least until a more perfect method of preserving the surface has been devised.

* Patent application No. 12658. 5/5/26.

International Congress for Testing Materials

FROM information now available, it appears that the papers which are to be presented at the International Congress of the International Association for Testing Materials, in London, next April, will be highly representative. Thus, Group A, which covers metals, comprises some seventy papers, of which Germany contributes fourteen, the United States and Sweden six each, France, Poland and Japan five each, and Austria and Belgium three each, while papers are also contributed from Italy, Switzerland, Czechoslovakia, and Uruguay. The British contribution includes sixteen papers, by various authorities, and it may be added that amongst the overseas authors will be found very many well-known names. The subjects included in Group A are as follows: "Behaviour of Metals as Dependent upon Temperature" (mechanical and chemical properties); "Progress of Metallography" (micro-macrography, X-ray interference, electron interference, equilibrium diagrams, non-metallic inclusions, solidification of ingots); "Light Metals and Their Alloys, Wear and Machinability."

The honorary secretary is Mr. K. Headlam-Morley, 28, Victoria Street, London, S.W. 1, to whom application should be made for further information about the Congress.

Canada's Record Mineral Production

INCREASES in the output of many mineral products and improved prices for several metals resulted in the establishment of 1936 as the record year in the mineral production of Canada, according to the a report issued on January 1 by the Dominion Bureau of Statistics at Ottawa. The output of all products of Canadian mines and quarries, including metals, fuels, non-metals other than fuels and structural materials, was valued at $360,540,000, or an average of nearly one million dollars a day for every day in the year, and represented an increase of over 15% over 1935, the previous peak.

Canadian gold production of 3,720,505 fine ounces at $130,329,000 represented 51% of the total value of all metals produced, and was a gain of 13% in value. Every gold-producing province recorded an increase. The total production was a Canadian record.

A record nickel production totalled 167,713,000 lb., valued at $43,471,000, an increase of 21% in quantity and 23% in value. During the year a quantity of nickel-copper ore was shipped by the British Columbia Nickel Mines, Ltd., to Japan.

Copper production at 414,137,000 lb. was some five million pounds less than in 1935, but the value rose to $38,665,000 from $32,312,000. Ontario copper mines showed an increase, but the output of Quebec, Manitoba, Saskatchewan and British Columbia was less. The Granby Mine, in the latter province, is to reopen next year, and this should mean a gain from that province in 1937.

Lead production constituted a record at 377,965,000 lb., and was a 9% increase over 1935. The chief source is the famous Sullivan Mine in British Columbia. Zinc production was 326,916,000 lb., valued at $10,765,000, as against 320,650,000 lb., at $8,937,000, in 1935, an increase of 2% in quantity and 8% in value.

Silver production reached 18,089,000 fine ounces, an increase of 9%. British Columbia mines account for 52% of the total. Platinum metals output at $7,741,000 was an all-time record.

The Parkes Desilvering Process

By C. C. DOWNIE

Although introduced some fifty years ago, the Parkes process is still one of the most economical methods of extracting silver from poor, argentiferous lead, and in this article the author describes the operation of the process.

THE original Parkes process, which was introduced some fifty years ago, is still applied to-day in a modified manner, in order to recover silver from poor argentiferous lead. When first employed it appeared to be applied to the recovery of precious metals from a wide variety of lead compositions from different smelting operations, but nowadays the system is only resorted to when there is a large accumulation of comparatively poor lead. In this respect the Parkes concentration of the small content of silver is still one of the most economical methods. The other early process of Pattinsonising, which was improved from a hand-method to a mechanical, and, finally, a steam-agitation method, has slowly fallen into disuse. The time factor appears to exert much influence, and the tendency to-day is to recover all precious constituents without delay.

Where rich gold and silver products are handled, they are melted on to lead in either reverberatory or blast furnaces. Arsenical lead is used according to the D'Hennin principle, so that most of the platinum metals will be recovered in the skimmings, when the lead is cleaned, which are later concentrated by repeated sulphurising. The cleaned lead is cupelled in "test" hearths, and the rich gold-silver alloy subjected to electrolysis. The lead is converted to litharge, which is mixed with the fume and flue dust from other smelting operations, and reclaimed for further use. Thus the arsenical lead continually circulates round the process, but a time comes when too much of this lead has accumulated, and it is then that the Parkes process is applied.

In some cases more litharge accumulates than a corresponding proportion of fume and flue dust, and, as an alternative, it is sweated on to an improvised liquation hearth: 40 cwt. of litharge are mixed with 5 cwt. of coal dross, and sweated at a dull-red heat. The litharge contains about 73% lead, 10–13% copper, and up to 1,400 oz. of silver per ton. Some of the poorer litharges contain only 100 oz. of silver, so that its richness varies somewhat widely. The sweating causes the easily fusible metal to flow to the small well of the hearth, leaving the hard, copper residues on the sloping bed. These residues are utilised in the blast furnace, increasing the copper content of the matte, and parting with their small silver content to the lead.

From the foregoing charge approximately 10 cwt. of these hard, copper residues are recovered. The lead is run into bogies and skimmed by perforated ladles, as in this manner what little gold has passed from the cupellation is partially recovered. These skimmings are later smelted, giving a lead containing 600 oz. of silver, 40 oz. of gold, and, on infrequent occasions, up to 10 oz. of platinum per ton. There are thus three products from the sweating process, namely, hard copper residues, skimmings, and lead.

When lead is required for addition to the "test" hearth, it is this lead which is used. It is usually cast in the form of thin plates from the ladle, which are later piled up at the side of the "test." This liquated lead contains from 100–400 oz. of silver, and averages about 1 oz. of gold per ton.

As a result of purchased raw materials coming to hand which contain appreciable lead, there is a continual increase of lead on the premises, and, in order to get rid of it, all silver is first recovered by the Parkes process. It is advantageous to use a lead for picking up the precious constituents in the smelting, which already contains some silver, and it is an unsatisfactory practice to use very poor lead. For this reason the process continues, with the arsenical lead traversing the system, until too much of it accumulates.

Many of the "test" hearths in this country appear to be of small dimensions, and have a capacity of some 10 cwt. When many tons of poor lead have accumulated the cupellation would become unduly expensive, and the somewhat antiquated Parkes process acts as a short cut. By this means the content of silver is concentrated in the zinc which is added, and comparatively soft lead is obtained which is practically free from silver.

The lead should be cleaned thoroughly to remove arsenic and antimony, but in this country it is simply skimmed to remove the bulk of these impurities. In the light of recent tin research a more rapid separation could have been effected, but at present the old system is persevered with.

Antimony is not capable of retaining much silver in the lead when the zinc reacts, unless present in the region of 1%; but it exerts a detrimental influence in that the crusts are slow to rise, and this is experienced in much more extreme instances with arsenic. A few points per cent. of arsenic are sufficient to delay appreciably the separation, and the continued addition of fresh zinc is necessary. Thus the careless cleaning of lead takes its toll in the subsequent Parkes process, but, as remarked, it is only infrequently applied.

Operating the Process

Detailed descriptions of the Parkes system have appeared in numerous works on the metallurgy of silver, and the point has repeatedly been stressed that cleaning of the lead is an integral part in the rapidity and ultimate success of the process. Where the D'Hennin process is used, however, care is taken to see that all lead contains arsenic, so as to ensure that metals of the platinum group will be concentrated in the skimmings. Most of the actual platinum remains in the lead, together with palladium, which are later recovered from the products of the cupellation, and, as D'Hennin originally pointed out, iridium and its associates, ruthenium, rhodium and osmium, collect in the arsenical skimmings, wherein nickel arsenide acts as the nucleus.

This slow and circuitous system is still used to-day by precious metal firms, through want of enterprise in applying improved methods, so that arsenic abounds in the process. When the lead has to be transferred to the Parkes process it is cleaned to some extent by adding litharge, exposing for periods to the air, and finally skimming. The lead is cast in pig-moulds, and the pigs placed in an iron kettle and melted.

A record taken of the time occupied in treating the lead, from the charging of the pigs to the removing of the zinc crusts, and subsequent steaming of the lead, showed that this averaged three days. Most of this time was occupied as a result of the imperfect initial treatment of the lead prior to casting as pigs. As regards tonnage, 96 cwt. of lead were charged, and after treatment gave 53 cwt. of soft lead for disposal. The average silver content of the lead was 1,000 oz. per ton, and after treatment was reduced to approximately 5 oz. per ton.

Although practically all the silver is thus drawn off with the zinc crusts, it will be noted that in so doing some 43 cwt. of the lead are sacrificed. In view of the impurities present a small addition of zinc had to be made either six or seven times, using about 40 lb. of this metal successively. Thus the 96 cwt. of lead received a total of about 2¼ cwt. of zinc.

As most of the zinc is removed by skimming after alloying to the silver, this means that the resulting 53 cwt. of lead contain but little zinc, if properly conducted, and most of the latter is eliminated by steaming. The earlier practice of gathering practically all the little gold by the first addition of zinc is seldom followed with the foregoing process, as there is so little to contend with. The successive lots of 40 lb. of zinc are simply weighed off, added to the molten lead in the kettle, and frequently stirred. When the crusts are seen to form in profusion on the surface, they are skimmed off and another charge of zinc added. The purer the lead the cleaner is the separation, but, in view of the imperfect removal of arsenic, is slow. Instead of adhering to any predetermined formula, the zinc additions are continued so long as appreciable silver exists in the lead. This is checked by an assay of the silver content, following the removal of each of the final batches of zinc charges.

When worked in this manner the crusts have accumulated some 2 tons of lead, together with most of the added zinc and all the silver. Thus 96 cwt. of lead, containing 1,000 oz of silver, have the latter concentrated in about 40 cwt. of crusts. This lead should be sweated in order to further concentrate the silver, and in the larger smelting works the resulting residue is distilled to reclaim the zinc. When used for odd lots this outlay on plant is not considered justified and the crusts are simply charged on to the lead-cleaning furnace prior to cupelling.

It has been stated that when a certain limit of zinc is overstepped during cupellation, silver tends to volatilise, but, despite this, some of the modern firms have been known to place the concentrated zinc crusts directly on the "test."

This application of the Parkes process gives no consideration to platinum and palladium, which have been removed previously, but a close examination revealed that tellurium, on certain occasions, had passed through and accumulated in the zinc crusts. What little of this element is present is more frequently removed previously, and does not reach the litharge. After the crusts have been finally separated, a hood is placed over the kettle, in order to maintain the heat, and steam passed in to oxidise the zinc, when the soft lead is ready for disposal.

Reviews of Current Literature

The Reaction in the Basic Open-Hearth Furnace

THE purpose of this investigation is the determination of the proportion of oxygen in the molten basic steel during the open-hearth process. It must be realised that the system of reaction is not a closed one, as carbon monoxide escapes continuously as long as the molten metal contains enough carbon for reactions with the oxides of the slag. A second influencing factor is the gas phase which continuously brings fresh oxygen to the process. Therefore an action of two forces is present in the furnace: (1) Of the reducing influence of the carbon in molten metal; and (2) of the oxidising influence of the gas phase, it is shown that the process of decarbonisation is composed of three parts: the reaction of ferrous oxide in the molten steel with the carbon forming carbon monoxide to a small extent, which remains dissolved in the molten metal; the liberation of the dissolved carbon monoxide from the molten steel to the gas phase; and the subsequent liberation of the carbon monoxide, absorbed in the molten steel by the two former processes from the slag.

Due to the different speed and combinations of the reactions the upper and lower limit of the proportion of carbon monoxide and oxygen in the molten material are fixed for different temperatures. The upper limit is given by the proportion of oxygen which corresponds with the equilibrium between molten metal and slag; the lower limit is given by the equilibria between the carbon and the oxides dissolved in the molten steel.

These theoretical considerations are checked by very careful experiments. They are concerned with :—

1. The extraction of samples for the determination of the proportion of oxygen. For this purpose a special vacuum vessel is developed, whose design and use is described in detail. The result of extracting examples by different methods are compared.
2. The determination of the coefficient of emissiority of molten steel by optical instruments as well as by thermoelectric tungsten-molybdenum elements.
3. The viscosity of the slag. It is characterised by the thickness of the layer formed by slag running down an inclined plane.

The result of the investigations is as follows: The proportion of oxygen in the molten steel in the basic process is very near to the possible lower limit as long as decarbonisation takes place. In consequence of this fact the speed at which the oxygen is consumed by decarbonisation is much higher than the speed at which carbon monoxide is liberated, and the subsequent liberation of oxygen from the slag.

This result is contrary to the observation that the proportion of oxygen in the molten steel corresponds to the equilibrium between the molten material and the slag; the chemical theory of equilibrium does not hold as long as the carbon is reacting vigorously.

Communications by Gerhard Leiber from the Kaiser-Wilhelm Institute of Research on Iron and Steel. No. 306.

Silver : Its Properties and Industrial Uses

THIS addition to the group of circulars on metals, issued by the Bureau of Standards of the U.S. Department of Commerce, is intended to present, in one place, the more important facts concerning silver. From the traditional point of view, silver is ranked among the precious metals. It has, however, an important position in the industrial field, and it is the latter aspect which is considered. The information given is based upon a survey of the engineering uses of silver which has been made. The principal source of information has been the papers on various aspects of silver which have been published, but much assistance has been given by the research laboratories of a large number of commercial, chemical, and metallurgical concerns in the U.S.A. and abroad.

The circular contains useful information concerning the properties and industrial uses of silver, and the authors emphasise the variation in physical properties by mechanical working and heat-treatment; the chemical properties are discussed with respect to resistance to corrosion; and considerable attention is given to the alloy systems, particularly those of the base metals, which enjoy relatively high consumption.

In order that the information could be adequately presented, it has been arranged in three parts. The first part deals with the physical, chemical, and technologic properties of the pure metal. The second part presents the available data concerning the alloys of silver with a number of the commercially important base metals. The final part deals with the industrial uses of silver, mainly electrical, chemical, and bactericidal.

By B. A. RODGERS, IRL C. SCHOONOVER, and LOUIS JORDAN; published by U.S. Department of Commerce. Copies may be obtained from the Superintendent of Documents, Washington, D.C., U.S.A. Price 10 cents.

POWDER METALLURGY

Metal powder has been known from antiquity, but industrial manufacture in large quantities is a comparatively recent development. The subject was discussed by Mr. J. C. Chaston, B.Sc., A.R.S.M., in a recent paper before the Midland Metallurgical Societies, an extract from which is given in this article.

THE first step towards the establishment of an industry of powder metallurgy such as now exists, may be said to have been taken just about 100 years ago by a young man who was later to become Sir Henry Bessemer. He found that " gold powder," although made from brass worth 9d. per lb., was only obtainable at a cost of 112s. per lb. This led to the development of a bronze-powder process which laid the foundation of his prosperity, and is said to have brought him a profit of £3,000,000 sterling in the 30 years during which he retained interest in it, and enabled him to afford those experiments in steel manufacture which culminated in the Bessemer converter. The most extraordinary precautions were taken to keep the process a secret—it was carried out in a building with no windows (only skylights)—and for 40 years no one entered the building, with the exception of Bessemer and his three brothers-in-law, who alone worked the process. By suitable choice of alloy, a wide range of coloured powders were produced, and these were further coloured by heating so as to produce oxide films on the surfaces.

Bessemer's Enterprise

For many years, however, the manufacture of silver-coloured powder was unsuccessfully attempted. Aluminium was not available, and no white alloys yielded good flakes. The problem was eventually solved by Bessemer by depositing tin or brass powder in a chemical tinning bath similar to that used for tinning common brass pins. Bessemer's enterprise attracted many imitators and competitors. Some he bought out, and with others he came to terms. He supplied the whole of the German industry with powder at a 25% discount. Just when he retired from the business, in about 1880, handing it over to his surviving brother-in-law, manufacture was once more commenced in Germany and this time by a new process, the stamp-mill process.

The Stamp Mill Process

Until about five years ago the stamp-mill process remained the only method for making leaf-like paint powders. It is fairly cheap to operate, and it is well suited for producing paint powder from aluminium as well as from " bronze." The process consists of subjecting the metal to the action of stamps in a series of mills, in which it is beaten out and broken up into flake-like particles. In order to prevent consolidation of the product, it is usual to use progressively lighter stamps as disintegration proceeds, and also to add small amounts of stearine or olive oil. The metal which is fed to the first mill is usually in the form of sheet clippings about $\frac{1}{4}$ in. square and $\frac{1}{10}$ in. thick, or less. These are often cut from edge trimmings and similar sheet scrap. The " bronze " powders are made from metal ranging in composition from pure copper to 70–30 brass, according to the shade required, whilst commercially-pure aluminium is used for " aluminium bronze " powders.

After leaving the mill, the powder, although of size and shape required, is relatively dull and lustreless, and it is necessary to subject it to a polishing operation. This, an important and often dangerous operation, on account of the danger of explosion, is carried out in a horizontal drum, through which passes a shaft carrying radial arms fitted with short, stiff bristles. The shaft is rotated for some hours at about 100 r.p.m., to cause the brushes to rub the particles against the side of the drum, and polish them. Choice of lubricant is of considerable importance to the speed of operation and the character of the surface finish.

This stamp-mill process had a long innings as the sole commercial process for the production of paint powders. Manufacture was confined to a family group of German producers. Just before the war, however, demand abroad led to the erection of mills in Canada, America and France. Then, during the war, production was started in this country, and successfully carried out by Armstrong-Whitworth and Company, as well as elsewhere. It had, however, several disadvantages. The output is not large, control of particular size and shape is not easy, and when aluminium powders are made, it must be regarded as a hazardous process, as aluminium powder may in certain circumstances form an explosive mixture with air, and some disastrous explosions have occurred in its production.

Impact Ball Mill

In an endeavour to overcome these difficulties, a process has been developed by The Hametag Company, of Copenick, Berlin. The action of this " impact ball mill " is precisely the same as that of the stamp mill, but impact is produced, not by stamps, but by a shower of falling balls, from a series of longitudinal fins, like shelves. The balls are small in size, and occupy about one-half of the volume of the mill. The great advantages of this mill are that it can be maintained full of an inert gas which, besides definitely guarding against any risk of explosion, can be used to remove the particles as soon as they have been reduced to the desired size.

The first plant to operate this process was opened in this country in 1932, a second being started in France two years later. The powder removed from the mill is delivered directly to the polishing drum at its side, thus eliminating any intermediate handling. It is said to be necessary to add occasionally small amounts of an oxidising substance to the mills with the aluminium, otherwise the powder produced in the slightly reducing atmosphere has such a clean, reactive surface that it is pyrophoric and liable to ignite on being discharged. In order to maintain the closest control over the product, the extreme step is therefore taken of mounting the whole of the mill on one arm of a weighing machine, and so obtaining a continuous record of the weight of charge at all times. The output is from 10 lb. to 60 lb. of powder per hr., 24 hrs. per day.

Other Shapes of Powder

For many purposes, powders of other shapes are required, often from metals not nearly so malleable. The same metal can often be powdered by several processes, each of which produces a distinctive shape of particle. Powders can often be made either from the metal itself or from one of its compounds. and these may be in either the solid, liquid or gaseous states. Almost all metals can be fractured across the crystal either by machining or repeated working, but some metals can be pulverised by fracture on cleavage planes, and others by breaking the crystals away from one another, after suitable preliminary treatment. Many molten metals can be atomised by an air or steam blast, and aluminium can be powdered by stirring the metal while it is solidifying, while metal vapours can often be condensed to droplets. Metal powders have been made from chemical compounds by reduction of a solid compound by heating in a stream of hydrogen, by replacement of one metal in solution by another metal in conditions which

result in the deposition of a powdery product, by electro-deposition from a solution or molten electrolytic under conditions which result in a powdery mass or a dispersion of fine particles, or by the thermal decomposition of a gaseous compound—in particular a metal carbonyl.

Magnesium Powder

In making magnesium powder special milling cutters are used simply to cut small chips from a block of the solid metal, and these irregularly-shaped, slighty-curved particles are graded by the use of woven-wire sieves.

Another process is based on the principle that if all impact is confined between the particles themselves they will pound each other to pieces. The Hametag Eddy Mill uses this principle and consists of a casing in which are mounted two large fans. These are rotated in opposite directions at high speed and set up a vigorous disturbance in the atmosphere inside, the main effect of which is to establish two opposing eddies. Any material inside the mills is thus caught up in one or other of the eddies, and hurled round at high speed. In the central part of the machine the particles collide and here pound and bend one another until they are broken up. This has been operated in Germany since 1923. The chief product has been iron powder for the magnetic cores of the leading coils used in the German telephone system.

Metals such as antimony and bismuth, which have a well-marked cleavage plane, do not behave like malleable metals and can readily be reduced to powder by grinding in a single ball mill, or on a small scale in a pestle and mortar.

Grinding in a Ball Mill

A method of making powdered metals which can be utilised with a limited number of metals and alloys is to impart to them the property of intercrystalline brittleness, and then to break the crystals apart by some such means as grinding in a ball mill. This principle has been used with success for powdering iron and also nickel-iron alloys. When making iron powder, the metal has been produced as a fine-grained, brittle deposit by electro-deposition. When powdering nickel-iron alloys, however, the alloy is first made in a brittle form by suitable melting procedure, and rendered fine-grained by hot-rolling. The alloy usually consists of iron with 70 to 90% of nickel. It is made by omitting the usual deoxidisers or manganese and, magnesium, when making the alloy from Mond or electrolytic nickel and Armco iron.

It was found that the ingots, although really nothing but a collection of large crystals weakly cemented together, would hold strongly enough to allow them to be hot-rolled at a high temperature. By this means the crystals can be broken down and reduced to a size fine enough to give fine particles. In practice, hot-rolling is done in a series of stepped rolls, the process being so adjusted that by the time the last roll is reached, the temperature is too low for hot-rolling to continue satisfactorily. The metal then breaks up in the last pass, and emerges as a shower of small fragments about 4 in. long, 1½ in. wide and ¼ in. thick, which are collected into a heap with shovels. These small fragments are pulverised in ball mills, sieved, insulated, pressed to shape and heat-treated to give magnetic powder cores.

Aluminium can be granulated direct from the molten metal by directing a stream of steam or compressed air against a stream of molten aluminium. It is produced as a dark grey, more or less spherical powder. It is used for calorising, for thermit, in ammonal explosives, in fireworks and as a precipitant for gold and silver in the cyanide process. Lead powder is also made by a similar process, and is used in this country for protective paints. It is produced in the form of very small spherical particles, and when mixed with oil yields a very good protective paint.

A large number of metal compounds can be reduced to the form of metallic powders, either by heating the finely-divided solid in a stream of hydrogen at a temperature below the melting point, or by precipitation from a solution. Tungsten, molybdenum, iron, nickel and cobalt are examples of metals which have been industrially produced by reduction of their oxides. The manufacture of tungsten and molybdenum is, of course, the first stage in the production of these metals in the ductile form, and is carried out on a very large scale.

Thermal Decomposition of Gaseous Compounds

Finally, mention must be made of the new process developed in Germany by which powders are made by the thermal decomposition of gaseous compounds, in this case the metallic carbonyls. Iron carbonyl, $Fe(CO)_5$, and nickel carbonyl $Ni(CO)_4$ are gaseous above 130° C. and 43° C., respectively, and on heating to higher temperatures they decompose, yielding the metal and carbon monoxide. If the decomposition is properly carried out, the metal can be obtained in the form of almost perfect spheres. They are made by introducing the gas into a large container, so that decomposition takes place in the hot, free space, and not in the neighbourhood of the walls. A method which has been patented is to mix cool carbonyl vapour with a stream of hot inert gas, the mixing being carried out in a vessel having cooled walls. There is thus no tendency for decomposition to occur by the deposition of a film of metal on the walls of the container. Iron carbonyl is usually decomposed below 400° C., and the reaction is assisted by the presence of a little freshly decomposed iron and by traces of ammonia. The powders so obtained are remarkably pure, but they invariably contain appreciable amounts of carbon and oxygen. Carbonyl powders have found an application in the manufacture of magnetic cores, radio-tuning coils, and similar purposes.

Sintered Carbides

Methods of powder metallurgy have alone made possible the production of the hard sintered carbides, such as Widia, Carboloy, etc., used for cutting tools and where extreme hardness and abrasion resistance are required. These are made by mixing carbides of tungsten and molybdenum in the powdered form with small amounts of nickel and cobalt powders, which, on sintering, form the cement which holds the hard particles together. The carbides are made by heating the metals with lampblack in a controlled atmosphere, the mixed powder pressed, and then sintered at about 650° C. to yield a soft, chalky intermediate product. After this has been formed to the rough shape required by cutting, the material is finally heated at about 1,350° C. in hydrogen. More recently, it has been proposed to make nickel, iron and nickel-iron alloys in a state of unusual purity, free from manganese and other deoxidisers, by sintering powders made by the carbonyl process. Carbonyl iron is probably the purest form of iron commercially obtainable.

A probable valuable use of powder methods would appear to lie in the development of new alloys, and in particular of mixtures of metals with non-metals, which can be made by no other method. Fine-grained iron throughout with small particles of silicon uniformly dispersed throughout is an example of such material. The silica particles hinder grain growth, and such iron finds application in the manufacture of certain types of vacuum tubes. Welding rods in which the flux is incorporated have also been made by powder methods. For such special purposes the method has great possibilities, and if in the future these are extended there should be no lack of methods for producing any kind, shape and size of metal powder which may be desired.

The fourth tilting open-hearth furnace, with a daily output capacity of 250 tons, has been put into operation at the Orjonikidze Metallurgical Works in Mariupol. The four open-hearth furnaces of this plant have an output capacity of 1,900 tons of steel per day.

Business Notes and News

National Savings Schemes in Works

One of the problems confronting every employer is that of the employee who has grown old in the service of the firm. All wise employers realise the importance of helping those they employ so to order their affairs that financial worries and anxieties are, as far as possible, minimised. Many of the large business organisations in the country have, for that reason, set up provident schemes of one kind or another for the benefit of the workers engaged in their undertakings. Employers operating on a smaller scale frequently find, however, that they cannot carry the large obligations those schemes involve. Such employers may now be well able to meet their requirements by invoking the assistance of the National Savings Committee which has a variety of schemes to suit differing needs.

The Committee's National Savings Provident Scheme is one that calls for special attention. It has a flexibility that enables it to be adjusted to the demands of any individual firm, whether large or small, and it can be so applied as to offer one or both of the two following benefits—endowment provision for a member on retirement and provision for his dependants should a member die while still in the service of the firm. Another useful facility offered is the National Savings Club Schemes. This has been specially designed to offer a good sound basis of management for Christmas clubs, holiday clubs, and all the other kinds of share-out clubs by means of which so many people employed in business put a bit of money aside through the course of the year.

Steelworks Extensions, New Coke Ovens

The active state of the iron and steel industries is making heavy demands upon the coke industry, and has resulted in a scarcity of that essential commodity in certain areas. To some extent the iron and steelworks of North Lincolnshire depend upon South Yorkshire supplies of blast-furnace coke, and many schems of coke-oven extension are being carried out in this area, with the object of meeting the demand. New coke ovens are to be erected at the Appleby-Frodingham steelworks, part of the organisation of the United Steel Companies. Supplies of coke are now mainly obtained from the Rothervale branch of the companies, but it is intended to install a modern coking and by-product recovery plant at the steelworks. In addition, the sintering plant is to be extended, and its capacity doubled.

Developments are in progress at the Lincolnshire works of J. Lysaght Ltd. It has been decided to add 23 ovens to the existing battery of 47 coke ovens. Further, a light railway is being built from the works to the proposed wharf on the Trent, which is to be equipped with electrically-driven transporter cranes for the movement of raw materials to the works and finished steel from the works.

New Cunard-White Star Liner

The order for the new Cunard-White Star liner recently placed with Messrs. Cammell, Laird and Co., of Birkenhead, will make 1937 a boom year for this area. Important orders in hand include the aircraft-carrier, *Ark Royal*, which will be launched in April, and the new battleship *The Prince of Wales*, the keel for which was recently laid.

The new liner is intended for service between Liverpool and the United States. It is understood that the new vessel will be between 30,000 and 40,000 tons and will have a speed of 22 to 23 knots. It is stated that she will be the first of a fleet of six vessels for the company's intermediate service based on Liverpool and London. It will be remembered that in July last it was announced that the Cunard-White Star Company planned to reorganise its fleet by building new liners at a total cost of about £10,000,000. The number, it was stated, would probably be eight or more, and they would be used to capture the North Atlantic traffic.

Machine-Tools Makers Busy

Many machine-tool manufacturing firms have orders in hand which will keep them fully occupied for the next two years, and it is understood that further substantial orders have been placed for Russia. These are included in the £4,000,000 worth of orders placed in this country by the Soviet Government for engineering equipment. Among the principal centres which will benefit from these contracts are Manchester, Halifax and Keighley.

Metallizing Kerbs

An experiment is being carried out at the Liverpool entrance of Queensway Tunnel, with a view to keeping the cast-iron kerbs surrounding the toll-booths constantly visible to motorists. Two metals are being tried, zinc and aluminium, in order to determine which will stand up best to atmospheric conditions. If the experiment is a success, the method is likely to be applied on a very much wider scale, because it offers a relatively cheap method for indicating kerbs at critical places. It would probably assist in solving some of the lighting problems associated with night driving as the bright lustre of these metals would reflect headlights, and give a good indication of road position on the darkest nights. The process should offer no insurmountable difficulty because metal can be sprayed on stone kerbs as well as on iron kerbs. Metal can, in fact, be sprayed on any metallic or non-metallic surface without the use of flux and without preheating the object to be coated.

Millom and Askam Reconstruction

The directors of the Millom and Askam Hæmatite Iron Company announce that, subject to the capital reorganisation schemes having the aproval of the court, they propose to pay the preference dividend for the twelve months ended September 30 last as soon as possible after the scheme comes into effect. The amount in issue after reorganisation will be £683,321, divided into £390,889 7 % cumulative participating Preference shares of £1 and £292,432 Ordinary shares of 5s.

Under the scheme approximately two-thirds of the Ordinary share capital is to be cancelled, so that a sum of £610,836 will become available for the assets to be written down. Of the nominal amount of the then issued Ordinary capital of £292,432, in 1,169,728 Ordinary shares of 5s. each, 266,460 have to be distributed among the Preference shareholders in proportion to the arrears of dividend accrued and arrears to September 30, 1935, will be cancelled. The remaining 903,268 Ordinary shares of 5s. each will be retained by the Ordinary shareholders.

Sheffield Activity

The steel works of Sheffield seem to create a record one month with the object of breaking it the next month. They are reaping the advantages of reorganisation and the installation of new equipment during the depression by increased output, which is steadily increasing as new units of production come into operation. Further extensions and improvements to plant, however, are being pushed forward to enable manufacturers to deal with the growing volume of business and overtake some of the arrears of delivery of steel billets and other semi-finished products.

As might be expected after a long depression, the question of finding sufficient skilled men to man the new units of production, particularly in fine steels, is a difficult problem. Men who had found other occupations during the depression are being brought back to the works, and young men are being specially trained in steel departments in readiness for the working of new shops and plant to be completed next year.

Mr. G. T. Lunt, who has been managing director of Bradley and Foster, Ltd., Darlaston, for the past thirteen years, has received a presentation from his co-directors and shareholders in recognition of his work for the firm.

Mr. W. V. Waite, M.I.Mech.E., A.M.I.E.E., has resigned his position as commercial manager of Messrs. Davy Bros., Ltd.

Mr. Lewis Chapman, whose whole time is now taken up by the steel companies in the B.S.A. group, has resigned from the board of the Birmingham Small Arms Co., Ltd.

The Mond Nickel Co. announce the appointment of Mr. Ivon A. Bailey as general manager of the Clydach Refinery. For the past five years Mr. Bailey has been general manager of the works of Messrs. Henry Wiggin and Co., Ltd., Birmingham, a subsidiary of the Mond Nickel Co., Ltd.

This appointment does not involve any change in the general executive organisation of the company. Mr. Bailey will be responsible to Mr. A. Parker Hague, who, as general manager of operations, will, as hitherto, control all operations of the Mond Nickel Co. and its subsidiaries in Great Britain.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100 0 0

ANTIMONY.

English	£76 0 0
Chinese	62 10 0
Crude	34 0 0

BRASS.

Solid Drawn Tubes	lb.	11½d.
Brazed Tubes	„	13½d.
Rods Drawn	„	10d.
Wire	„	9¼d.
*Extruded Brass Bars	„	5⅝d.

COPPER.

Standard Cash		£54 5 0
Electrolytic		59 9 0
Best Selected		58 10 0
Tough		58 1 0
Sheets		87 16 0
Wire Bars		59 16 0
Ingot Bars		59 16 0
Solid Drawn Tubes	lb.	12¾d.
Brazed Tubes	„	12¾d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 3 1½
‡Ferro Tungsten	„	0 3 0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL 2-4% Carbon, scale 11/- per unit	ton	29 15 0
NOMINAL 4-6% Carbon, scale 7/- per unit	„	22 7 6
NOMINAL 6-8% Carbon, scale 7/- per unit	„	21 12 0
NOMINAL 8-10% Carbon, scale 7/- per unit	„	21 12 0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33 0 0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36 0 0
§Guar. max. 0·5% Carbon, scale 12/6 per unit	„	37 10 0
‡Manganese Metal 97-98% Mn.	lb.	0 1 2
‡Metallic Chromium	„	0 2 5
§ Ferro-Vanadium 25-50%	„	0 12 8
§ Spiegel, 18-20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	6 5 0
20/30% basis 25%, scale 3/6 per unit	„	9 0 0
45/50% basis 45%, scale 5/- per unit	„	11 15 0
70/80% basis 75%, scale 7/- per unit	„	16 15 0
90/95% basis 90%, scale 10/- per unit	„	28 17 6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	12 5 0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20-25%	ton	22 0 0
§ Ferro-Molybdenum, Molyte	lb.	0 4 6
§ Calcium Molybdate	„	0 4 2

FUELS.

Foundry Coke—		
S. Wales	£1 10 0 to	1 12 0
Scotland	—	1 8 0
Durham		1 4 6
Furnace Coke—		
Scotland	1 5 0 to	1 6 0
S. Wales	1 4 6 to	1 5 0
Durham	—	1 1 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£73 10 0
*Commercial Ingots		54 10 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 10
*Cored Bars	„	0 1 0

MANUFACTURED IRON.

Scotland—	
Crown Bars, Best	£10 10 0
N.E. Coast—	
Rivets	10 10 0
Best Bars	13 0 0
Common Bars	9 5 0
Lancashire—	
Crown Bars	10 10 0
Hoops £10 10 0 to	12 0 0
Midlands—	
Crown Bars	10 10 0
Marked Bars	13 0 0
Unmarked Bars from	9 7 0
Nut and Bolt Bars £8 17 6 to	9 7 6
Gas Strip	11 7 6
S. Yorks.—	
Best Bars	10 15 0
Hoops from	11 7 6

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	10d.
*Cored Bars	„	1/-
†Strip	„	1/0½
†Sheet to 10 W.G.	„	1/1
†Wire	„	1/1½
†Rods	„	1/-
†Tubes	„	1/3¼
†Castings	„	1/1½
†10% Phos. Cop. £30 above B.S.		
†15% Phos. Cop. £35 above B.S.		
†Phos. Tin (5%) £30 above English Ingots.		

PIG IRON.

Scotland—	
Hematite M/Nos.	£4 18 0
Foundry No. 1	4 10 6
„ No. 3	4 8 0
N.E. Coast—	
Hematite No. 1	4 18 0
Foundry No. 1	4 3 6
„ No. 3	4 1 0
„ No. 4	4 0 0
Silicon Iron	—
Forge	4 0 0
Midlands—	
N. Staffs Forge No. 4	4 3 0
„ Foundry No. 3	4 6 0
Northants—	
Foundry No. 1	4 6 6
Forge No. 4	4 0 6
Foundry No. 3	4 3 6
Derbyshire Forge	4 3 0
„ Foundry No. 1	4 9 0
„ Foundry No. 3	4 6 0
West Coast Hematite	5 3 6
East „ „	—

SWEDISH CHARCOAL IRON AND STEEL.

Export pig-iron, maximum percentage of sulphur 0.015, of phosphorus 0.025.

Per English ton	Kr. 121

Billets, single welded, over 0.45 Carbon.

Per metric ton	Kr. 265-335
Per English ton	£13 17 6/£17 12 6

Wire Rods, over 0.45 Carbon.

Per metric ton	Kr.315-365
Per English ton	£16 10 0/£19 2 6

Rolled Martin iron, basis price.

Per metric ton	Kr.210-230
Per English ton	£11 0 0/£12 0 0

Rolled charcoal iron, finished bars, basis price.

Per metric ton	Kr.310
Per English ton	£16 5 0

f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£42 0 0
„ Braziery	40 0 0
„ Wire	—
Brass	24 0 0
Gun Metal	40 0 0
Zinc	12 0 0
Aluminium Cuttings	74 0 0
Lead	20 0 0
Heavy Steel—	
S. Wales	3 5 0
Scotland	2 17 6
Cleveland	3 0 0
Cast Iron—	
Midlands	2 15 0
S. Wales	2 14 0
Cleveland	3 5 0
Steel Turnings—	
Cleveland	2 5 0
Midlands	2 0 0
Cast Iron Borings—	
Cleveland	1 7 6
Scotland	1 18 0

SPELTER.

G.O.B. Official	—
Hard	£21 0 0
English	23 5 0
India	19 10 0
Re-melted	19 10 0

STEEL.

Ship, Bridge, and Tank Plates	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	8 10 0
„ „ (Marine) „	—
„ „ (Land), N.E. Coast	8 10 0
„ „ (Marine) „	8 17 6
Angles, Scotland	8 7 6
„ North-East Coast	8 7 6
„ Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 10 0
Light Rails £8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic £6 17 6 to	7 2 6
Medium Basic £6 12 6 and	7 0 0
Soft Basic	5 10 0
Hoops £9 10 0 to	9 15 0
Manchester	
Hoops £9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.	10 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ⅜ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£231 0 0
English	231 5 0
Australian	231 0 0
Eastern	233 12 0
Tin Plates I.C. 20 × 14 box	18/9

ZINC.

English Sheets	£32 15 0
Rods	34 0 0
Battery Plates	—
Boiler Plates	—

LEAD.

Soft Foreign	£28 11 0
English	30 10 0

*McKechnie Brothers, Ltd. Jan. 12. † C. Clifford & Son, Ltd., Jan. 12. ‡ Murex Limited, Jan. 12. Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Jan. 12.